東京帝國大學

農學部紀要

第十二卷

JOURNAL

OF THE

COLLEGE OF AGRICULTURE

TOKYO IMPERIAL UNIVERSITY

VOLUME XII 12

AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE LIBRARY
No. 33442
8-AUG 1950
COIMBATORE

TOKYO
PUBLISHED BY THE UNIVERSITY

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On the Distribution of Decapod Crustaceans inhabiting the Continental Shelf around Japan, chiefly based upon the Materials collected by S. S. Sôyô-Maru, during the Year 1923-1930.

By

Yu Yokoya,

Fishery Institute, College of Agriculture, Tokyo Imperial University.

With seventy-one Figures in the Text.

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Introduction.

The biological survey of the continental shelf of Japan, surrounding Honsyû, Sikoku and Kyûsyû, done by S. S. Sôyô-Maru, the

surveying ship of the Imperial Fishery Experimental Station of Tokyo, during the years 1923–1930, has brought us numerous interesting animals obtained from 658 stations. All specimens of decapod crustaceans in the collection were allotted to me for examination. The number of decapod species collected amounts to 292, among which 52 or more and one variety are new to science, 3 are members of new genera, while 33 have not hitherto been reported from Japanese waters. Of course, much more of the species of marine decapod crustaceans have been reported from Japan. However, the depth at the stations in the present survey being 18–684 m., mostly 100–400 m., many shallow water forms were not obtained in the collection; thus the number of crustaceans for the present study is considerably reduced.

Viewing from the stand point of the animal distribution, we can learn many interesting facts from the collection. In many of decapod crustaceans of Japan, the known localities of individual species have been reported independently and fragmentally without consideration about its extent of distribution, so that we are quite ignorant of its geographical range. But now some farther points and many connecting localities of many species were revealed, so that we are enabled to know fairly well the distribution of many species. In the present paper special attention is paid to the distribution of each species suggesting some hints to the hydrography of the waters surrounding Honsyû, Sikoku and Kyûsyû.

The precise notes of the stations are shown in "Annotation of the Oceanographical Research, Vol. III, Nos. 1, 2" and in "Semiannual Report of Oceanographical Investigation, Report 48".

II. Systematic List of the Species.

TRIBE PENAEIDEA.

Family **Penaeidae** SP. BATE.

Subfamily Aristeinae ALCOCK.

Genus **ARISTEUS** DUVERNOY.

No species of this genus has hitherto been known from Japanese waters.

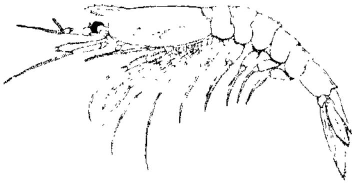
1. Aristeus japonicus n. sp.

(Text-fig. 1.)

LOCALITIES: *Station 383, east of Owase, Mie-ken, 353 m. deep.* December 4, 1927. 1 male.
Station 399, near Owase, Mie-ken, 61 m. deep. February 29, 1928. 1 male.

Near *Aristeus virilis* (SP. BATE)[1], differs in the following points:–

Rostrum with five to seven teeth above, of which two behind the orbital margin. Scaphocerite not thickened at the margin, nearly as long as the peduncle of the first antenna. Anterior half of the carapace carinates in median line. A small carina commencing at the third abdominal somite terminates posteriorly to a point in each of the posterior four somites.



Text-fig. 1. *Aristeus japonicus* n. sp. (×1/2)

Subfamily Penaeinae ALCOCK.

Genus **HALIPORUS** SP. BATE.

2. Haliporus sibogae DE MAN.

DE MAN, 1911, p. 38.

LOC. Station 381, east of Owase, Mie-ken, 329 m. deep. December 3, 1927. 1 male and 5 females.
Station 382, east of Owase, Mie-ken, 180 m. deep. December 4, 1927. 1 female.
Station 386, off mouth of Ôigawa River, 100 m. deep. December 11, 1927. 1 female.
Station 400, east of Owase, Mie-ken, 379 m. deep. March 2, 1928. 1 male.

DISTRIBUTION: Flores Sea (521 m.); Strait of Makassar (450 m.); Banda Sea (462 m.); near Ki Islands (394 m.); Japan: Kagosima Bay, off Maisaka, Sizuoka-ken and above localities.

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1) *Hemipenaeus virilis*, SP. BATE, 1888, p. 303, pl. 44, fig. 4; DE MAN, 1911, p. 6.

Genus **SOLENOCERA** LUCAS.

3. *Solenocera distincta* (DE HAAN).

Penaeus distinctus, DE HAAN, 1849, p. 194.
Solenocera distincta, BALSS, 1914, p. 5 (cited previous synonyms and literature)

LOC. Station 113, south of Inuboe-zaki, 196 m. deep. March 2, 1927. 1 female.

Station 283, Suruga Bay, 123 m. deep. July 4, 1928. 1 female.

Station 286, east of Omae-zaki, 123 m. deep. July 4, 1928. 1 male.

Station 290, east of Omae-zaki, 143 m. deep. July 5, 1928. 1 broken male.

Station 304, east of southern Miyazaki-ken, 241 m. deep. July 12, 1928. 1 female.

Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1 female.

Station 422, west of Kagosima-ken, 88 m. deep. July 15, 1929. 1 broken specimen.

Station 434, south of Gotô Isls., 238 m. deep. July 18, 1929. 2 males.

Station 449, north-west of Gotô Isls., 155 m. deep. July 1929. 1 male and 1 female.

Station 465, west of Hirato, 106 m. deep. July 24, 1929. 22, 1 female.

Station 503, near Oki Isls., 146 m. deep. August 18, 1929. 4 males.

Station 521, near middle between Oki Isls. and Mihonoseki, 86 m. deep. August 23, 1929. 1 male and 3 females.

Station 524, coast of Tottori-ken. 88 m. deep. August 23, 1929. 1 female.

Station 540, near Kyô-gasaki, 123 m. deep. August 25, 1929. 2 females.

Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 2 males.

Station 580, Toyama Bay, 135 m. deep. July 29, 1930, 1 female.

Station 582, Toyama Bay, 176 m. deep. July 30, 1930, 1 male.

DISTRIBUTION: Japan: Sagami Bay (50–150 m.), Ise Bay, Wakanoura, Wakayama-ken, and above localities.

Genus LEPTOPENAEUS KISHINOUYE.

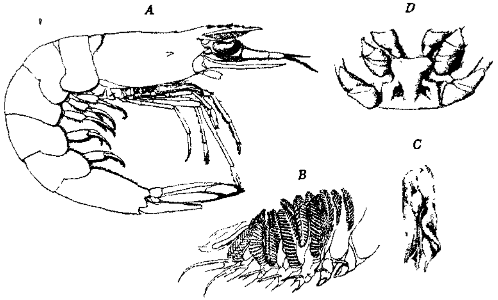
4. *Leptopenaeus Kyushuensis* n. sp.

(Text-fig. 2.)

LOC. Station 296, east of Tanegasima Isl., 219 m. deep. July 11, 1928. 1 female.

Station 317, coast of Miyazaki-ken, 97 m. deep. July 16, 1928. 1 male.

Station 428, west of Amakusa Isls., 119 m. deep. July 16, 1929. Many of both sexes.



Text-fig. 2. *Leptopenaeus kyusyuensis* n. sp.
A, Entire animal, view from right side (×2). *B*, Branchiae in position. *C*, Petasma (×5). *D*, Thelycum (×5).

The species is nearly allied with *Metapenaeus coniger* WOOD-MASON[1], but differs in the following points:–

The rostrum is short, does not attain the distal end of the second peduncular segment of the first antenna, and is armed with seven or eight teeth above. In these teeth the posterior one is much remoted in position and situated behind the anterior fourth of the carapace.

[1] ALCOCK, 1906, p. 25, pl. 4, fig. 12.

The eye is large and dorsally rather concave. In the first antenna the first peduncular segment is longer than the second, which is a little shorter than twice the length of the third. The scaphocerite of the second antenna is as long as or a little longer than the peduncle of the first antenna. The pereiopods are all provided with an exopodite. In the abdominal somites, from the third to the sixth are dorsally carinated. The sixth is long and almost as long as the carapace excluding rostrum.

Branchial formula:

	h	*i*	*k*	*l*	*m*	*n*	*o*
Pleurobranchiae	1	1	1	1	1	1	—
Arthrobranchiae	2	2	2	2	2	—	—
Podobranchiae	1	—	—	—	—	—	—
Mastigobranchiae	1	1	1	1	1	—	—

The petasma in natural position is entirely margined; the left lobe is longer than the right. The anterior inner projection of the latter is inserted into the pocket of the former. In the thelycum, the median plate is broad and its anterior margin is almost straight and converges posteriorly. On each side of the posterior part of this median plate, there is a wall which is distinguishable from the median plate by a deep depression.

Genus CERATOPENAEUS KISHINOUYE.

5. *Ceratopenaeus dalei* (RATHBUN).

Parapenaeus dalei, RATHBUN, 1902, p. 42.
Ceratopenaeus dalei, YOKOYA, 1930, p. 527.

Loc. Station 102, south-west of Kinkazan, 37 m. deep. November 10, 1926. 2 females.
Station 110, south of Inuboe-zaki, 59 m. deep. March 2, 1927. 1 female.
Station 112, south of Inuboe-zaki, 37 m. deep. March 2, 1927. 1 male and 2 females.
Station 128, south of Kinkazan, 48 m. deep. March 7, 1927. 13 males and 30 females.
Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 5 males, 2 females and 1 young specimen.
Station 173, near Kinkazan, depth unrecorded, October

28, 1923. 1 male and 2 females.
Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 male and 1 female.
Station 323, Bungo Strait, 88 m. deep. July 21, 1928. 2 males.
Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 5 males and 3 females.
Station 370, south of Atumi, Aiti-ken, 91 m. deep. August 10, 1928. 2 males and 2 females.
Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 3 females.
Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 male.
Station 447, near Gotô Isls., 90 m. deep. July 20, 1929, 1 broken specimen.
Station 519, east of Mihonoseki, 81 m. deep. August 20, 1929. 1 male and 3 females.
Station 521, between Oki Isls. and Mihonoseki, 86 m. deep. August 23, 1929. 1 male and 3 females.
Station 524, coast of Tottori-ken, 88 m. deep. August 23, 1929. 3 males and 2 females.
Station 633, north of Oga, 78 m. deep. August 18, 1930. 1 young specimen.
Statian 635, north of Oga, 46 m. deep. August 18, 1930. 1 male, 1 female and 4 youngs.

DISTRIBUTION: Moji, Hakodate, Mutsu Bay and above localities. On the pacific side Station 173 is the northern limit of the distribution. Station 420 is the deepest in the vertical distribution.

6. ***Ceratopenaeus mogiensis*** (RATHBUN).

Parapenaeus mogiensis, RATHBUN, 1902, p. 39.
Metapenaeus mogiensis, ALCOCK, 1906. p. 29, Pl. 5, Fig. 15; RATHBUN, 1906, p. 904, Pl. 20, Fig. 3.
Penaeopsis mogiensis, BALSS, 1914, p. 9.

LOC. Station 267, Suruga Bay, 64 m. deep. November 18, 1927. 1 male.
Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 2 males and 2 females.

DISTRIBUTION: Japan: Mogi, Nagasaki, Sagami Bay and above localities; Hongkong; Malayan Archipelago; Hawaii; Andaman; Ceylon; Marabar; Red Sea.

Genus ERITHROPENAEUS KISHINOUYE.

7. *Erithropenaeus akayebi* (RATHBUN).

Parapenaeus akayebi, RATHBUN, 1902, p. 39.
Erithropenaeus akayebi, YOKOYA, 1930, p. 526.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 2 males and 1 female.
Station 470, between Simonoseki and Iki Isl., 37 m. deep. July 25, 1929. 1 female.

DISTRIBUTION: Japan: Kyûsyû, Inland Sea, Mutsu Bay and above localities.

8. *Erithropenaeus acclivis* (RATHBUN).

Parapenaeus acclivis, RATHBUN, 1902, p. 41.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 6 males and 9 females.

DISTRIBUTION: Japan: Mogi, Kagosima Bay and above locality.

Genus PARAPENAEUS SMITH.

9. *Parapenaeus fissurus* (BATE).

Penaeus fissurus, BATE. 1881, p. 180; 1888, p. 263, Pl. 36, Fig. 1.
Parapenaeus fissurus, ALCOCK, 1905, p. 520; 1906, p. 31, Pl. 5, Fig. 16; DE MAN, 1911, p. 79, Pl. 8, Fig. 25; BALSS, 1924, p. 10.

LOC. Station 347, south-east of Sikoku, 126 m. deep. July 29, 1928. 1 female.
Station 405, southern Bungo Strait, 136 m. deep. April 29, 1928. 1 female.
Station 416, south of Kôti, 97 m. deep. December 7, 1928. 2 females.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Tokusima-ken and above localities; Philippine Islands; Talili Bay; Andaman; Malayan Archipelago.

10. *Parapenaeus rectacutus* (BATE).

Penaeus rectacutus, BATE, 1888, p. 266, Pl. 36, Fig. 2.
Metapenaeus rectacutus, WOOD-MASON, 1891, p. 274.
Parapenaeus rectacutus, ALCOCK, 1906, p. 33, Pl. 6, Fig. 19; DE MAN, 1911, p. 82.

LOC. Station 383, east of Owase, Mie-ken, 353 m. deep. December 4, 1927. 2 females.
Station 386, off mouth of Tenryûgawa River, 100 m. deep. December 11, 1927. 1 male.

DISTRIBUTION: off Matuku, Fiji Islands; Philippine Islands, between Bohol and Zebu; off Pulicut; Bali Sea; near Paternoster Islands; Makassar Strait; from Japanese waters it has not hitherto been reported.

Genus PENAEOPSIS A. MILNE-EDWARDS.

11. *Penaeopsis ensis* (DE HAAN).

Penaeus monoceros ensis, DE HAAN, 1849, p. 192, Pl. 46, Fig. 2.
Penaeus intermedius, KISHINOUYE, 1900, p. 21.
Metapenaeus ensis, ALCOCK, 1906, p. 24.
Penaeopsis ensis, BALSS, 1914, p. 8.

LOC. Uwazima, Ehime-ken, market. December 1, 1928. 1 female.

DISTRIBUTION: Singapore; Port Blair; Japan: Kôti-ken (Province Tosa) and above locality. I have some specimens from Mie-ken and Wakayama-ken.

Genus TRACHYPENAEUS ALCOCK.

12. *Trachypenaeus curvirostris* (STIMPSON).

Penaeus curvirostris, STIMPSON, 1860, p. 44; KISHINOUYE, 1900, p. 23, Pl. 6, Fig. 4; DE MAN, 1907, p. 436.
Parapenaeus curvirostris, RATHBUN, 1902, p. 38.
Trachypenaeus curvirostris, BALSS, 1914, p. 11; YOKOYA, 1930, p. 526.

LOC. Station 93, south of Todo-saki, 163 m. deep. November 6, 1926. 1 male and 2 females.
Station 102, south-west of Kinkazan, 37 m. deep. November 10, 1926. 1 broken specimen.
Station 123, north-west of Siwoya-zaki, 137 m. deep. March 11, 1927. 1 male.

Station 132, near middle between Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 1 female.

Station 159, north-east of Inuboe-zaki, 208 m. deep. November 13, *1926. 1 female.*

Station 161, near Siwoya-zaki, 76 m. deep. November 16, 1926. 1 female.

Station 166, south of Kinkazan, depth unrecorded. November 21, 1926. 4 females.

Station 168, near Kinkazan, depth unrecorded, November 21, 1926. 1 male and 2 females.

Station 173, near Kinkazan, depth unrecorded, October 28, 1923. 3 males and 2 females.

Uwazima, Ehime-ken, market. December 1, 1928. 3 females.

DISTRIBUTION: Arafura Sea; Japan: south of Corea, Kyûsyû, Sikoku and Honsyû; but on the Pacific side Station 93 is the northern limit of known localities, while on the side of Japan Sea, it distributes northwards to the western coast of Hokkaidô.

Genus PENAEUS FABRICIUS.

13. Penaeus semisulcatus DE HAAN.

DE HAAN, 1849, p. 191, Pl. 46, Fig. 1; DE MAN, 1898, p. 677; 1911, p. 97, Pl. 9, Fig. 31; ORTMANN, 1890, p. 450; BALSS, 1914, p. 14.
Penaeus ashiaka, KISHINOUYE, 1900, p. 14, Pls. 3 and 7, Fig. 4; RATHBUN, 1902, p. 38.

LOC. Station 405, east of southern Miyazaki-ken, 136 m. deep. May 5, 1928. 1 male.

DISTRIBUTION: Japan: from Kyûsyû to Tokyo Bay. Formosa; Philippine Islands; Malayan Archipelago; New-Guinea; Singapore; Indian coast; Red Sea; Madagaskar.

Subfamily Sicyoninae ORTMANN.

Genue SICYONIA H. MILNE-EDWARDS.

14. Sicyonia cristata DE HAAN.

DE HAAN, 1849, p. 195, Pl. 45, Fig. 6; STIMPSON, 1860, p. 43; RATHBUN, 1902, p. 41; BALSS, 1914, p. 15.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep.

February 26, 1928. 3 males and 3 females.

DISTRIBUTION: Japan: Kagosima, Nagasaki, Mogi, Sagami Bay and above locality.

15. *Sicyonia lancifer japonica* BALSS.

BALSS, 1914, p. 16.

LOC. Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 female.

DISTRIBUTION: Japan: Sagami Bay and above locality.

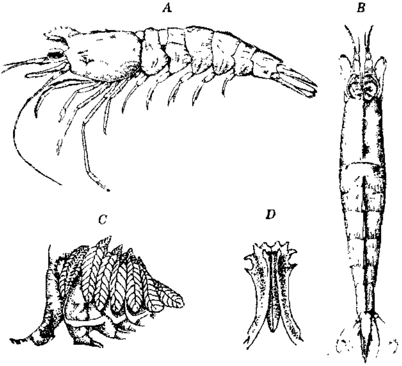
16. *Sicyonia curvirostris* BALSS.

(Text-fig. 3.)

BALSS, 1914, p. 17.

LOC. Station 179, south of Simoda, 189 m. deep. June 28, 1927. 1 female.

Station 188, south-east of Omae-zaki, 214 m. deep. June 30, 1927. 1 female.



Text-fig. 3. *Sicyonia curvirostris* BALSS.
A, Entire animal, view from left side (×1). *B*, Entire animal, dorsal aspect (×1). *C*, Branchiae in position (×2). *D*, Petasma (×5).

Station 259, Suruga Bay, 188 m. deep. November 15, 1927. 1 female.
Station 277, south of Omae-zaki, 91 m. deep. July 2, 1928. 1 male.
Station 279, Suruga Bay, 155 m. deep. July 2, 1928. 1 male.
Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 female.
Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 1 female.
Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 1 male.
Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 1 female.
Station 450, west of Gotô Isls., 205 m. deep. July 22, 1929. 1 female.

According to my examination the branchial formula is as follows:

	h	*i*	*k*	*l*	*m*	*n*	*o*
Pleurobranchiae	1	1	1	1	1	1	—
Arthrobranchiae	1	1	1	1	1	—	—
Podobranchiae	—	—	—	—	—	—	—
Mastigobranchiae	—	—	1	1	1	—	—

That is, mastigobranchiae are wanted on two maxillipeds, but the specimens coincide with the original description, though it is very brief.

Family **Sergestidae** DANA.

Genus **SERGESTES** MILNE-EDWARDS.

17. Sergestes prehensilis BATE.

BATE, 1881, p. 193; 1888, p. 385, Pl. 71.

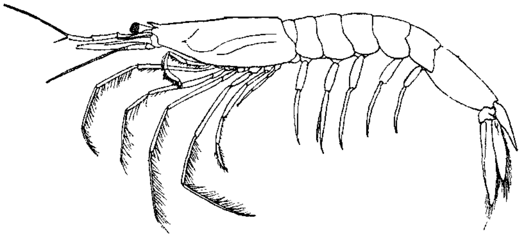
LOC. Station 262, Suruga Bay, 604 m. deep. November 17, 1927. 1 female.

DISTRIBUTION: Japan: west of Sunosaki, Sagami Bay and Suruga Bay.

18. *Sergestes nipponensis* n. sp.

(Text-fig. 4.)

LOC. Station 21, south-east of Siwoya-zaki, 209 m. deep. June 21, 1926. 1 female.
Station 25, east of Siwoya-zaki, 525 m. deep. July 2, 1926. 1 female.
Station 253, Sagami Bay, 452 m. deep. November 9, 1927. 1 female.



Text-fig. 4. *Sergestes nipponensis* n. sp. (×2)

Near *Sergestes orniculum* KRÖYER. Rostrum somewhat more acute and forwards directed. No tubercle noticeable on inner margin of eye. Flagellum of second antenna missing in all the specimens. Terminal joints of the legs have much longer hairs. No tooth on both of anterior two legs.

TRIBE EUCYPHIDEA.

Family **Pasiphaeidae** BATE.

Genus **LEPTOCHELA** STIMPSON.

19. *Leptochela gracilis* STIMPSON.

STIMPSON, 1860, p. 42; BATE, 1888, p. 860, Pl. 189, Fig. 2; BALSS, 1914, p. 19.

LOC. Station 90, north of Todo-saki, 152 m. deep. November

3, 1926. 1 specimen.

Station 95, between Todo-saki and Kinkazan, 141 m. deep. November 7, 1926. 2 males and 2 females.

Station 110, south of Inuboe-zaki, 59 m. deep. March 2, 1927. 1 specimen.

Station 123, north-east of Siwoya-zaki, 137 m. deep. March 11, 1927. 1 male.

Station 128, south of Kinkazan, 48 m. deep. March 7, 1927. 1 probably male.

Station 135, east of Kinkazan, 159 m. deep. November 21, 1925. 2 probably females.

Station 136, east of Kinkazan, 194 m. deep. November 21, 1925. 1 specimen.

Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 1 egg-bearing female.

Station 470, between Simonoseki and Iki Isls., 37 m. deep. July 25, 1929. 1 probably female.

Station 493, off Hamada, Simane-ken, 124 m. deep. August 12, 1929. 1 probably female.

Station 503, near Oki Isls., 146 m. deep. August 18, 1929. 1 egg-bearing female.

Station 504, near Oki Isls., 106 m. deep. August 18, 1929. 1 egg-bearing female.

Station 575, north of Noto, 123 m. deep. July 28, 1930. 2 probably males.

Station 582, Toyama Bay, 176 m. deep. July 30, 1930. 1 specimen.

DISTRIBUTION: Tschemulpho, Corea; Japan: Kii Strait, Kagosima and above localities.

Genus **PASIPHAEA** SAVIGNY.

20. ***Pasiphaea sivado*** (RISSO).

ALCOCK, 1901, p. 59, Investigator-Illustrations, Pl. 3, Fig. 6; KEMP, 1910, p. 409; BALSS, 1914, p. 20.

As other papers than the above cited were not within reach to identify the species, some doubts are retained.

LOC. Station 247, Kii Strait, 128–159 m. deep. November 8,

1927. 1 specimen.
Station 312, Bungo Strait, 622 m. deep. July 15, 1928. 1 probably male.

DISTRIBUTION: it has wide distribution. Atlantic Ocean: coast of Europe; Mediterranean; Adriatic Sea; Red Sea; Bay of Bengal; Andaman Sea; Japan: Bôsyû and above localities.

Family **Stylodactylidae** BATE.

Genus STYLODACTYLUS MILNE-EDWARDS.

21. Stylodactylus bimaxillaris BATE.

BATE, 1888, p. 855, Pl. 138, Fig. 3; BALSS, 1914, p. 27.

LOC. Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 1 egg-bearing female.
Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

DISTRIBUTION: Admirality Isls.; Japan: Sagami Bay and above localities.

Family **Pandalidae** BATE.

Genus PANDALUS LEACH.

22. Pandalus platyceros BRANDT.

BRANDT, 1851, p. 125; DOFLEIN, 1902, p. 635, Pl. 1, Figs. 1 and 2; RATHBUN, 1904, p. 44; BALSS, 1914, p. 28. (not *P. latirostris* RATHBUN) SCHMITT, 1921, p. 43, Pl. 14, Fig. 3.
P. robustus, STIMPSON, 1860, p. 57.

LOC. Station 591, south of Sado Isl., 311 m. deep. August 3, 1930. 1 male.

DISTRIBUTION: west coast of North America. Japan: east coast of Hokkaidô, Hakodate, Nagasaki and above locality.

23. Pandalus borealis KRÖYER.

RATHBUN, 1904, p. 35; 1929, p. 8.

LOC. Station 604, north-east of Sado Isl., 444 m. deep. August 10, 1930. 1 male.

DISTRIBUTION: Circumpolar. Greenland to Cape Cod; Bering

Sea to Columbia River; northern Europe; Japan: common in Niigata-ken, Toyama-ken, Isikawa-ken and Hukui-ken.

24. *Pandalus hypsinotus* BRANDT.

BRANDT, 1851, p. 125; DOFLEIN, 1902, p. 635, Pl. 4, Figs. 1 and 2; RATHBUN, 1902, p. 46; BRASHNIKOW, 1907, p. 114, Pl. 2, Fig. 9; BALSS, 1914, p. 29.

LOC. Station 474, northern Tusima Strait, 219 m. deep. July 28, 1929. 11 males and 4 females.
Station 584, Toyama Bay, 212 m. deep. July 30, 1930. 3 males and 1 female.
Station 600, north of Sado Isl., 168 m. deep. August 9, 1930. 1 male and 1 female.
Station 605, north of Sado Isl., 139 m. deep. August 10, 1930. 3 young specimens.
Station 606, north of Sado Isl., 117 m. deep. August 10, 1930. 3 males and 5 females.
Station 618, off Yamagata-ken, 135 m. deep. August 14, 1930. 1 male.
Station 628, off Akita-ken, 148 m. deep. August 17, 1930. 1 male.
Station 630, west of Oga, 150 m. deep. August 17, 1930. 1 male.
Station 646, west of Tugaru Strait, 123 m. deep. August 22, 1930. 7 young specimens.
Station 647, west of Aomori-ken, 86 m. deep. August 23, 1930. 1 male and 1 female.
Station 648, west of Tugaru Strait, 247 m. deep. August 23, 1930. 3 males and 1 egg-bearing female.
Station 658, north of Siriya-zaki, 113 m. deep. August 30, 1930. 1 female.

DISTRIBUTION: Unalasca; Bering Sea; Japan: Nemuro, Nagasaki and above localities. Nagasaki, when from market, it probably comes from northern seas.

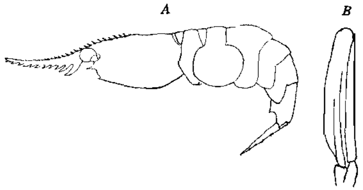
25. *Pandalus nipponensis* n. sp.

(Text-fig. 5.)

LOC. Station 18, near middle between Siwoya-zaki and Inuboe-

zaki, 583 m. deep. June 26, 1926. 1 egg-bearing female.
Station 157, near Inuboe-zaki, 76 m. deep. November 9, 1926. 1 male.
Station 159, north-east of Inuboe-zaki, 208 m. deep. November 13, 1926, 2 egg-bearing females.
Station 383, off Owase, Mie-ken, 353 m. deep. December 4, 1927. 1 male and 2 females.
Station 386, off Tôtômi, Sizuoka-ken, 100 m. deep. December 11, 1927. 1 egg-bearing female.
Station 400, off Owase, Mie-ken, 379 m. deep, March 2, 1928. 1 male.

Body rather robust; surface smooth and naked. Rostrum about one and one-fourth times as long as carapace. Median crest of



Text-fig. 5. *Pandalus nipponensis* n. sp.
A, View from left side, appendages removed (×1/2).
B, Antennal scale. Natural size.

carapace extending posteriorly as an obtuse carina to near the posterior margin, armed with twenty to sixteen movable spines, of which seven to five are behind the orbital sinus, and one more fixed tooth just behind the extremity of the rostrum. Lower limb of the rostrum with eleven teeth; the proximal one is the largest, diminishing gradually in size to the terminal one. Posterior part of rostrum a little deflexed, anterior half ascending, tip near the dorsal level of carapace. Eyes large, subspherical, with an ocelus. Antennal scale longer than five-sixths the length of carapace, oblong, extremity of blade subtruncate, slightly exceeds the spine. External maxilliped reaches the tip of the antennal scale. Right leg of second pair exceeding the tip of the antennal scale with the length of chela, carpus about twelve articulate; left leg about one and a half times as long as the

right, carpus divided into more than thirty articles. Sixth segment of abdomen shorter than twice of the breadth.

The species is near related with *P. hypsinotus* BRANDT, but it differs in the following points:–

Anterior dorsal carina of the carapace shows nearly a straight line in profile behind the orbital hiatus. Sixth abdominal somite broad, about one and two-thirds times as broad as long. The external maxilliped is longer (in *P. hypsinotus* it does not reach the tip of the antennal scale). The ocelus of the eye is distinct.

This species is recently very commonly known in the south-eastern coast of Honsyû, since the deep sea fishery commences. The colour in life is orange yellow in ground and dotted with deep red spots. In Tokyo it is known by the name of "Botan-yebi", i. e., rose-coloured prown.

Genus **PLESIONIKA** BATE.

26. ***Plesionika martia*** (A. MILNE-EDWARDS).

Pandalus martius, A. MILNE-EDWARDS, 1883, Pl. 21; RATHBUN, 1906, p. 914.
Plesionika martia, CAULLERY, 1896, p. 378, Pl. 15, Figs. 1–6; BALSS, 1914, p. 30.
Pl. semilaevis, BATE, 1888, p. 644, Pl. 113, Fig. 3.

LOC. Station 208, near Siwo-misaki, 219 m. deep. July 13, 1927. 3 males and 1 female.
Station 249, Sagami Bay, 229 m. deep. November 9, 1927. 1 male.
Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 1 male.
Station 367, south-east of Toba, Mie-ken, 291 m. deep. August 10, 1928. 1 female.
Station 382, near Owase, Mie-ken, 180 m. deep. December 4, 1928. 1 male.
Station 383, east of Owase, Mie-ken, 353 m. deep. December 4, 1928. 1 male and 2 females.
Station 441, south-west of Is. Gotô, 353 m. deep. July 9, 1929. 2 egg-bearing females.

DISTRIBUTION: Atlantic Ocean: Ireland, Biscaya Bay, Iberian Half Island; Mediterranean; Cape of Good Hope; Arabian Sea;

between Philippine Islands and Borneo; Sydney; Tasmanian Sea; Fiji Islands; Hawaii; Kermadec Islands; Japan: Sagami Bay and above localities. After T. URITA the species is very common in Kagosima Bay.

27. *Plesionika binoculus* (BATE).

Nothocaris binoculus, BATE, 1888, p. 656, Pl. 114, Fig. 2.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 7 males and 7 egg-bearing females.
Station 434, south of Is. Gotô, 238 m. deep. July 18, 1929. 1 egg-bearing female.
Station 493, off Hamada, Simane-ken, 124 m. deep. August 11, 1929. 2 males and 1 egg-bearing female.

DISTRIBUTION: Arafura Sea; Japan: after URITA very common in Kagosima Bay, and above localities.

28. *Plesionika rostricrescentis* (BATE).

Nothocaris rostricrescentis, BATE, 1888, p. 653, Pl. 114, Fig. 1.

LOC. Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 1 egg-bearing female.

DISTRIBUTION: off Ki Islands; it has not hitherto been known from Japanese waters.

29. *Plesionika hypanodon* DOFLEIN.

DOFLEIN, 1902, p. 615, Pl. 3, Fig. 1; BALSS, 1914, p. 30.

LOC. Station 183, Suruga Bay, 251 m. deep. June 29, 1927. 1 male.
Terminal half of the rostrum broken off in the specimen.

DISTRIBUTION: Japan: Sagami Bay and above locality.

30. *Plesionika brevirostris* BATE.

BATE, 1888, p. 650, Pl. 113, Fig. 5.

LOC. Station 381, east of Owase, Mie-ken, 329 m. deep. December 3, 1927. 2 males and 2 females.
Station 382, east of Owase, Mie-ken, 180 m. deep. December 4, 1927. 1 male.

DISTRIBUTION: Between Philippine Islands and Borneo; Japan is new for distribution.

Genus PARAPANDALUS BORRADAILE.

31. Parapandalus spinipes grandis (DOFLEIN).

Plesionika spinipes, BATE *var. grandis*, DOFLEIN, 1902, p. 618, Pl. 3, Figs. 3-5.
Parapandalus spinipes, (BATE) *var. grandis*, BALSS, 1914, p. 31.

LOC. Station 221, north-west of Muroto-zaki, 209 m. deep. July 20, 1927. 1 egg-bearing female.
Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 female.
Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 7 males and 5 females, 1 bears eggs.
Station 276, near Omae-zaki, 77 m. deep. July 2, 1928. 1 male and 1 female.
Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1 egg-bearing female.

Spines on the upper margin of the rostrum are more than fourty in the specimens.

DISTRIBUTION: Japan: Kagosima, Sagami Bay and above localities.

Genus HETEROCARPUS MILNE-EDWARDS.

32. Heterocarpus ensifer A. MILNE-EDWARDS.

A. MILNE-EDWARDS, 1881, p. 8; BATE, 1888, p. 638, Pl. 112, Fig. 4; ALCOCK, 1901, p. 107; BATHBUN, 1906, p. 917, Pl. 21, Fig. 7.

LOC. Station 303, east of Kagosima-ken, 364 m. deep. July 12, 1928. 1 female.
Station 382, east of Owase, Mie-ken, 180 m. deep. December 4, 1927. 3 males and 2 females, 1 bears eggs.
Station 386, off mouth of River Tenryû-gawa, 100 m. deep. December 11, 1927. 2 females, 1 bears eggs.
Station 400, east of Owase, Mie-ken, 379 m. deep. March 2, 1928. 1 female.
Mitani, Aiti-ken (market), December 3, 1927. 1 female.

DISTRIBUTION: Atlantic: West Indies; Indopacific: Andaman

Sea; between Philippine Islands and Borneo; Hawaii; New Britannia; Japan: Sagami Bay and above localities.

Family **Alpheidae** BATE.

Genus OGYRIS STIMPSON.

33. ***Ogyris orientalis*** STIMPSON.

STIMPSON, 1860, p. 36; YOKOYA, 1927, p. 171, Pl. 7, Figs. 1-16.
? *Ogyris sibogae*, DE MAN, 1911, p. 135.

LOC. Station 472, east of Is. Tusima, 130 m. deep. July 27, 1929. 1 specimen.
Station 483, north-west of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 specimen.
Station 493, off Hamada, Simane-ken, 124 m. deep. August 11, 1929. 6 specimens, 2 bear eggs.

DISTRIBUTION: Sulu Sea; Saleh Bay ?; Japan: Kagosima, Onahama and above localities.

Genus SYNALPHEUS BATE.

34. ? ***Synalpheus gravieri*** COUTIÈRE.

COUTIÈRE, 1905, p. 870; DE MAN, 1911, p. 216.
Alpheus prolificus, ORTMANN, 1890, p. 484.

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 2 egg-bearing specimens.
Station 449, north-west of Is. Gotô, 155 m. deep. July 22, 1929. 1 specimen.
Station 465, north of Is. Gotô, 106 m. deep. July 24, 1929. 1 egg-bearing specimen.
Station 484, north of Nagato, Yamaguti-ken, 93 m. deep. August 9, 1929. 1 specimen.

All the specimens before me are not preserved well, most of them are missing the legs and no specimen bears the larger cheliped.

DISTRIBUTION: Djibouti; Maldive Archipelago; China Sea; Japan: Tokyo Bay, Kagosima and above localities.

Genus ALPHEUS FABRICIUS.

35. *Alpheus gracilipes* STIMPSON.

STIMPSON, 1860, p. 31; DE MAN, 1888, p. 500, Pl. 21, Fig. 5; 1911, p. 380; ORTMANN, 1890, p. 488; COUTIÈRE, 1905, p. 901.

LOC. Station 294, north of Is. Tanegasima, 102 m. deep. July 10, 1928. 1 egg-bearing female.
Station 421, south of Is. Kosiki, 307 m. deep. July 15, 1929. 1 egg-bearing female.

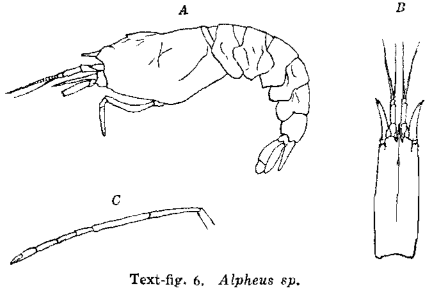
DISTRIBUTION: Tahiti; Marquesas Islands; Samoa Islands; Hawaiian Islands; New Caledonia; Ternate; Amboina; Bay of Batavia; Ceylon; Maledive Islands; Mahé; Djibouti; Dar-es-Salaam; from Japanese waters it has hitherto never been known.

36. *Alpheus sp.*

(Text-fig. 6.)

LOC. Station 308, southern Bungo Channel, 155 m. deep. July 14, 1928. 1 specimen probably male.
Station 345, near Muroto-zazi, 155–199 m. deep. July 29, 1928. 1 probably male.

Nearly related with *A. acutocarinatus* DE MAN[1] but it differs in



Text-fig. 6, *Alpheus sp.*
A, Entire animal. view from left side (×5). *B*, Carapace, dorsal aspect (×5). *C*, Terminal half of 2nd leg (×10).

[1] DE MAN, 1911, p. 401.

the following points:–

Carapace longer than one-half of abdomen, and surface uneven. Rostrum longer and reaches distal end of basal peduncular joint of 1st antenna. Telson much shorter and robust, about one-fourth as long as carapace. Second peduncular joint of 1st antenna somewhat more robust, one and a half times as long as the visible part of the first joint. Outer margin of the scaphocerite distinctly concave. External maxilliped rather robust; penultimate joint short, but a little longer than broad in lateral view. First pair of legs missing in both of the specimens. Second article of the carpus of second leg is a little longer than first; three following articles subequal in length, but fifth very slightly longer than the others.

37. ? *Alpheus ventrosus* H. MILNE-EDWARDS.

H. MILNE-EDWARDS, 1837, p. 352; COUTIÈRE, 1905, p. 882; DE MAN, 1911, p. 339.
Alpheus laevis, RANDALL, 1839, p. 141; DANA, 1852, p. 556, Pl. 35, Fig. 8; BATE, 1888, p. 555, Pl. 99, Fig. 3; ORTMANN, 1890, p. 487.

LOC. Station 469, near middle between Simonoseki and Is. Tusima, 91 m. deep. July 25, 1929. 1 probably male.

Chelipeds are unfortunately missing.

DISTRIBUTION: Akaba Bay; Red Sea; Indian Archipelago; Tahiti; Hawaiian Isls.; California; Japan: Tokyo Bay, Kagosima and above locality.

Family **Hippolytidae** ORTMANN.

Genus SPIRONTOCARIS BATE.

38. *Spirontocaris mororani* RATHBUN.

RATHBUN, 1902, p. 43, Text-fig. 16; YOKOYA, 1930, p. 529, Text-fig. 1.

LOC. Station 58, north-east of Todo-saki, 177 m. deep. July 28, 1926. 1 female.
Station 637, north of Oga, 145 m. deep. August 18, 1930. 1 male.
Station 648, west of Tugaru Strait, 247 m. deep. August 23, 1930. 1 male.

These specimens are also smaller than the type specimen described by RATHBUN, and very near those from Mutsu Bay, but the

specimen from Station 648 has a somewhat longer rostrum.

DISTRIBUTION: Japan: Muroran, Mutu Bay and above localities.

39. *Spirontocaris groenlandica* (FABRICIUS).

Astacus groenlandicus, FABRICIUS, 1775, p. 416.
Hippolyte groenlandica, MIERS, 1877, p. 62; ORTMANN, 1890, p. 501.
Spirontocaris groenlandica, RATHBUN, 1904, p. 61; 1929, p. 11; BALSS, 1914, p. 45.
Cancer aculeatus, FABRICIUS, 1780, p. 239.

LOC. Station 570, north-west of Noto, 260 m. deep. July 27, 1930. 1 female.
Station 648, west of Tugaru Strait, 247 m. deep. August 23, 1930. 1 egg-bearing female.

DISTRIBUTION: Kuril Islands; Kamtschatca; Bering Sea; Puget Sound; Davis Strait; Greenland; north-east coast of America. From Japanese waters it has not hitherto been recorded, but not rarely taken from north-west of Honsyû.

40. ? *Spirontocaris unalaskensis* RATHBUN.

(Text-fig. 7.)

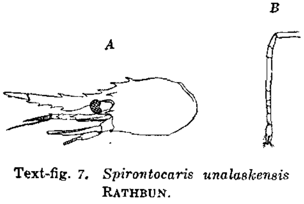
RATHBUN, 1902, p. 895; 1904, p. 74.

LOC. Station 609, near middle between Is. Sado and Oga, 669 m. deep. August 10, 1930. 3 males and 1 egg-bearing female.

Referable to this species, but it differs from the type specimen in the following points:-

Rostrum long, with more teeth: 5 or 6 above, 4 to 8 below. Flagella of first antenna shorter, but they are probably broken off the terminal halves. In the second antenna the peduncle is shorter. Third maxilliped longer, *nearly as long as rostrum.*

In the articles of the carpus of the second leg, the third is the longest, nearly



Text-fig. 7. *Spirontocaris unalaskensis* RATHBUN.

A, Carapace, view from left side. Nat. size.
B, Terminal half of 2nd leg (×2).

as long as the succeeding four articles together. The legs except posterior three pairs are provided with a rudimentary epipodite.

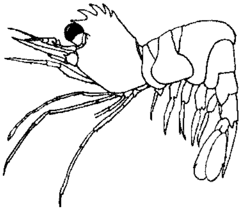
41. *Spirontocaris gibberosa* n. sp.

(Text-fig. 8.)

LOC. Station 26, north-east of Siwoya-zaki, 232 m. deep. July 2, 1926. 1 probably female.

Body robust. Carapace very high, keeled in the middle line, the keel is provided with five strong teeth, rostrum broken off. A supra-orbital and an antennal tooth, but no pterygostomian tooth. Abdomen much geniculated at third somite; pleura rounded in anterior four somites.

Eye pyriform, cornea much dilated. Antennal scale nearly as long as carapace. Third maxilliped exceeds a little the tip of the antennal scale. First leg missing in the specimen. In seven carpal articles of second leg, third the longest, fourth and seventh subequal, longer than any of remaining four, fifth the shortest. Third and fifth leg (fourth one missing in the specimen) similarly shaped, merus with a small spinule on posterior margin near the extremity.



Text-fig. 8. *Spirontocaris gibberosa* n. sp. (×2)

42. *Spirontocaris pusiola* (KRÖYER).

Hyppolyte pusiola, KRÖYER, 1841, p. 576.
Spirontocaris pusiola, RATHBUN, 1904, p. 99; 1929, p. 17.

LOC. Station 648, west of Tugaru Strait, 247 m. deep. August 23, 1930. 1 male.

DISTRIBUTION: Gulf of St. Lawrence to Chesapeake Bay; Bering Islands; southern Alaska to British Columbia; northern Europe; Iceland. From Japanese waters never hitherto been known.

43. *Spirontocaris leptognatha* (STIMPSON).

Hippolyte leptognatha, STIMPSON, 1860, p. 34; MIERS, 1879, p. 56.

LOC. Station 48, south-east of Todo-saki, 644 m. deep. July 9, 1926. 1 male.
Station 69, south-east of Siriya-zaki, 594 m. deep. July 26, 1926. 1 male.

DISTRIBUTION: Hokkaidô and above localities.

44. *Spirontocaris geniculata* (STIMPSON).

Hippolyte geniculata, STIMPSON, 1860, p. 34; ORTMANN, 1891, p. 503, *Pl. 37, Fig. 3.*
Spirontocaris geniculata, RATHBUN, 1902, p. 45; YOKOYA, 1930, p. 530.
Spirontocaris alcimede, DE MAN, 1907, p. 416, Pl. 32, Figs. 42–46.

LOC. Station 637, north of Oga, 145 m. deep. August 18, 1930. 1 young specimen.

DISTRIBUTION: Japan: Hakodate, Muroran, Tanagawa, Tokyo Bay, Inland Sea, Mutu Bay and above locality.

45. *Spirontocaris gracilirostris* (STIMPSON).

Hippolyte gracilirostris, STIMPSON, 1860, p. 34.
Spirontocaris gracilirostris, BALSS, 1914, p. 44.

LOC. Station 637, north of Oga, 145 m. deep. August 18, 1930. 1 male and 2 females.

DISTRIBUTION: Hokkaidô, Sagami Bay and above locality.

46. *Spirontocaris camtschatica* (STIMPSON).

Hippolyte camtschatica, STIMPSON, 1860, p. 164.
Spirontocaris camtschatica, RATHBUN, 1904, p. 94, Text-fig. 92; BALSS, *1914, p. 44.*
Eualus camtschatica, BRASHNIKOW, 1907, p. 164, Fig. 22.

LOC. Station 385, southern coast of Atumi, Aiti-ken, 18–23 m. deep. December 4, 1927. 1 male.

DISTRIBUTION: Arctic Alaska; Kamtschatca; Aleutian Islands; Bering Sea; Port Etches; Japan: Sagami Bay, Tokyo Bay and above locality.

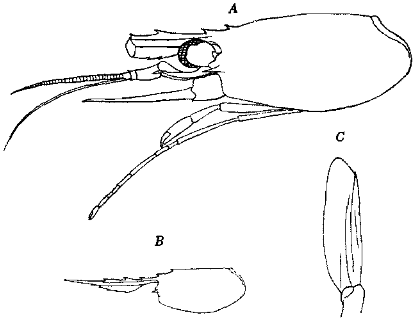
47. *Spirontocaris biunguis* RATHBUN.

(Text-fig. 9.)

RATHBUN, 1902, p. 899; 1904, p. 97.

LOC. Station 567, Yamato-Ridge, 620 m. deep. July 25, 1930. 1 egg-bearing female.

Station 601, north of Is. Sado, 454 m. deep. August 9, 1930. 1 egg-bearing female.



Text-fig. 9. *Spirontocaris biunguis* RATHBUN.
A, Anterior half of the animal, from Station 567 (×2).
B, Carapace of the specimen from Station 601. Nat. size.
C, Scaphocerite (×2).

The specimen from Station 567 is missing posterior three pairs of legs and the terminal half of the rostrum, but in other respects it is referable to the present species.

First leg stout; the chela finger nearly as long as two-thirds of palm. Second leg slender; in the carpal articles third the longest, distinctly longer than proximal two articles together.

Dimension:

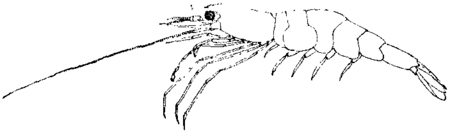
	Stat. 567	Stat. 601
Length of carapace, excluding rostrum	16.9 mm.	15.7 mm.
Length of free part of rostrum		16.1
Length of scaphocerite at the outer margin	11.7	11.5
Length of 6th abdominal somite	10.0	9.4
Length of telson	11.1	10.6

DISTRIBUTION: From Bering Sea to Oregon, 109–987 fathoms. Japan: above localities.

48. *Spirontocaris spathulirostris* n. sp.

(Text-fig. 10.)

LOC. Station 70, near middle between Siriya-zaki and Todo-saki, 285 m. deep. July 26, 1926. 1 specimen.
Station 474, north-west of Is. Tusima, 219 m. deep. July 28, 1929. 6 specimens.
Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 2 specimens.



Text-fig. 10. *Spirontocaris spathulirostris* n. sp. (×2).

The species is easily distinguishable from other species of this genus in the form of the rostrum. Anterior half carapace carinated in the medial line; the carina continuous to the upper laminar expansion of the rostrum. Rib of the rostrum nearly straight, directed slightly upwards and almost reaches the middle of scaphocerite. No upper limb on anterior half of the rostrum, the upper laminar expansion at the base is armed with about nine minute teeth; lower limb rather deep, usually provided with one tooth.

The abdomen is smooth-surfaced and dorsally rounded; sixth somite, which is nearly as long as the telson, is about two-thirds as long as the carapace excluding the rostrum. The pereiopods except posterior two pairs are provided with a rudimentary epipodite.

49. *Spirontocaris minuta* YOKOYA.

(Text-fig. 11.)

YOKOYA, 1930, p. 531, Text-fig. 2.

LOC. Station 609, near middle between Is. Sado and Oga, 669 m. deep. August 10, 1930. 1 probably male.

Rostrum with 6 or 7 teeth above and below. Posterior one or two of the upper teeth are behind orbital sinus. First leg is shorter than that of type specimen from Mutu Bay, and distinctly exceeds the eye but does not reach the end of basal peduncular joint of the first antenna. Specimen from Mutu Bay seems to be young.

Text-fig. 11. *Spirontocaris minuta* YOKOYA (×3).

Dimension:

Length of carapace including rostrum (in medial line)	14.3 mm.
Length of free part of rostrum	9.0
Length of 6th abdominal somite	5.9
Length of telson	6.3

DISTRIBUTION: Mutu Bay and above locality.

Genus **PARASPIRONTOCARIS** YOKOYA.

50. ***Paraspirontocaris kishinouyei*** YOKOYA.

YOKOYA, 1930, p. 536, Pl. 16, Figs. 1–6.

LOC. Station 572, north of Noto, 132 m. deep. July 27, 1930. 1 male.

DISTRIBUTION: Mutu Bay, ? Aiti-ken and above locality.

Family **Palaemonidae** BORRADAILE.

Subfamily Pontoniinae KINGSLEY.

Genus **UROCARIS** STIMPSON.

51. ***Urocaris longipes*** STIMPSON.

STIMPSON, 1860, p. 39.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 5 specimens.

DISTRIBUTION: Japan: Ousima and above locality.

Family **Oplophoridae** KINGSLEY.

Genus **OPLOPHORUS** A. MILNE-EDWARDS.

52. ***Oplophorus gracilirostris*** MILNE-EDWARDS.

(Text-fig. 12.)

A. MILNE-EDWARDS, 1881, p. 6; ALCOCK, 1901, p. 73; RATHBUN, 1906, p. 921.

LOC. Station 354, south of Tanabe, Wakayama-ken, 558 m. deep. August 4, 1928. 1 male.

Text-fig. 12. *Oplophorus gracilirostris* M.-E. Natural size.

DISTRIBUTION: West Indies; India; Hawaii. I have examined a specimen of this species from Okitu, Sizuoka-ken; any representative of this genus has not hitherto been reported from Japanese waters.

Family **Nikiidae** RISSO.

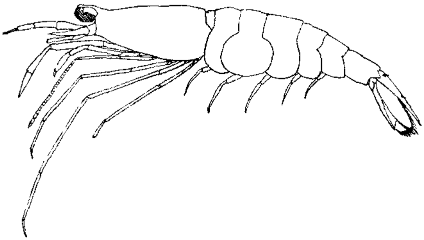
Genus **NIKA** RISSO.

53. Nika kotiensis n. sp.

(Text-fig. 13.)

LOC. Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 female.

Body moderately slender. Eye large, somewhat exceeds end of rostrum. Flagella of both antennae missing. Peduncle of first antenna long, a little shorter than one-third of the carapace; peduncle of second antenna nearly as long as the scale. Outer maxilliped rather stout and long, almost reaches the end of the antennal scale



Text-fig. 13. *Nika kotiensis* n. sp. (×2)

with the antepenultimate joint. First leg of right side missing, left one simple and scarcely reaches the middle of penultimate joint of outer maxilliped. Posterior four legs rather slender; second a little longer than the outer maxilliped, carpus subdivided into about sixteen articles in the left one (right one missing in the specimen). Third and fourth legs similar shaped and both longer than the preceding. The fourth exceeds the extremity of the third by the length of terminal two joints. In the last leg terminal joints missing.

Abdomen dorsally rounded. The telson, which is longitudinally sulcated, is dorsally armed with two pairs of spinules, and on the posterior margin there are also two pairs of spinules, the outer is shorter than the inner one.

Dimension:

Length of the carapace excluding the rostrum	6.3 mm.
Length of the abdomen including the telson	16.4
Length of the fourth leg about	18.0

Near *Nika processa* (BATE) and *N. japonica* DE HAAN, but from the former it differs in the larger eye, longer peduncle of second antenna, in unequal length of posterior legs and in armature on the telson; from the latter besides above characteristics it differs in longer maxilliped.

54. *Nika edulis* RISSO.

MILNE-EDWARDS, 1837, p. 364; 1849, Pl. 52, Fig. 1; ORTMANN, 1890, p. 528, Pl. 36, Fig. 24; BALSS, 1914, p. 60.

LOC. Station 214, Kii Strait, 166 m. deep. July 18, 1927. 1 broken specimen.

Station 308, east of southern Miyazaki-ken, 155 m. deep. July 14, 1928. 1 female.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 egg-bearing female.

Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 1 male.

Station 402, east of Kagosima-ken, 86 m. deep. August 15, 1928. 1 egg-bearing female.

Station 470, near middle between Simonoseki and Is. Iki, 37 m. deep. July 25, 1929. 1 male.

Station 471, north of Simonoseki, 90 m. deep. July 27,

1929. 1 egg-bearing female.

DISTRIBUTION: Mediterranean; North Sea; West Indies; Cape of Good Hope; Ceylon; California; Panama Bay; Japan: Tokyo Bay, Sagami Bay, Kôti, Kagosima Bay, Nagasaki and above localities.

Family **Glyphocrangonidae** BORRADAILE.

Genus GLYPHOCRANGON A. MILNE-EDWARDS.

55. ***Glyphocrangon hastacauda*** BATE.

BATE, *1888*, p. 519, Pl. 93, *Fig. 5*; ALCOCK, 1901, p. 131.

LOC. Station 272, west of Suno-saki, 612 m. deep. November 18, 1927. 1 female.

DISTRIBUTION: Ceylon; Japan: Sagami Bay and above locality.

Family **Crangonidae** BATE.

Genus CRANGON FABRICIUS.

56. ***Crangon affinis*** DE HAAN.

DE HAAN, *1894*, p. *183*; YOKOYA, 1930, *p.* 541.
Crangon propinquus, STIMPSON, 1860, p. 25; RATHBUN, 1902, p. 42; BRASHNIKOW, 1907, p. 84.
Crangon hakodatei, RATHBUN, 1902, p. 42, Text-fig. 15.
Crangon consobrinus, DE MAN, 1907, p. 405.
Crangon cassiope, *DE* MAN, *1907*, p. *406*.

LOC. Station 81, east coast of Aomori-ken, 172 m. deep. November 1, 1926. 1 female.
Station 90, north of Todo-saki, 152 m. deep. November 3, 1926. 10 specimens.
Station 100, south of Kinkazan, 137 m. deep. November 8, 1925. 1 female.
Station 173, near Kinkazan, depth unrecorded. October 1923. Many specimens, some larger ones bear eggs.
Station 474, north of Is. Tusima, 219 m. deep. July 28, 1929. 1 male and 1 female.
Station 486, north of Nagato, Yamaguti-ken, 139 m. deep. August 11, 1929. 1 male.
Station 541, north of Kyôga-saki, 150 m. deep. August 25, 1929. 4 males and 4 females.

Station 593, east of Is. Sado, 219 m. deep. August 3, 1930. 1 male and 1 female.

Station 637, north of Oga, 145 m. deep. August 18, 1930. 1 female.

Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 1 male.

Station 653, Tugaru Strait, 108 m. deep. August 24, 1930. 1 male and 3 females.

DISTRIBUTION: Japan and Corea.

57. *Crangon dalli* RATHBUN.

RATHBUN, 1902, p. 889; 1904, p. 119, Text-fig. 60.

LOC. Station 33, south-east of Kinkazan, 331 m. deep. July 16, 1926. 4 males and 1 female.

Station 56, east of Todo-saki, 212 m. deep. July 16, 1926. 1 male and 2 females.

Station 58, north-east of Todo-saki, 177 m. deep. July 18. 1926. 19 specimens without eggs and 6 youngs.

Station 59, north of Todo-saki, 168 m. deep. July 19, 1926. 1 male and 1 female.

Station 70, near middle between Siriya-zaki and Todo-saki, 285 m. deep. July 26, 1926. 3 males, 4 females and 2 youngs.

DISTRIBUTION: Washington; Alaska; Bering Sea; Kurile Islands. Japan: above localities. From Japanese waters it has not hitherto been known.

58. *Crangon sagamiense* BALSS.

BALSS, 1914, p. 63, Figs. 38, 39.

LOC. Station 41, north of Kinkazan, 177 m. deep. July 9, 1926. 1 egg-bearing female.

Station 95, near middle between Todo-saki and Kinkazan, 141 m. deep. November 7, 1926. 1 male and 1 egg-bearing female.

Station 126, near middle between Kinkazan and Siwoya-zaki. 146 m. deep. March 7, 1927. 1 male.

Station 146, east of Siwoya-zaki, 201 m. deep. November

30, 1925. 1 female.

Station 236, north of Suno-saki, 251 m. deep. November 6, 1927. 1 male.

Station 255, Sagami Bay, 263 m. deep. November 10, 1927. 1 male.

Station 381, east of Owase, Mie-ken, 329 m. deep. December 3, 1927. 1 male and 2 egg-bearing females.

Station 400, east of Owase, Mie-ken, 379 m. deep. March 4, 1928. 1 egg-bearing female.

Station 434, south of Is. Gotô, 238 m. deep. July 18, 1929. 2 males.

Station 453, east of Is. Saisyû-tô, 148 m. deep. July 23, 1929. 2 probably females.

DISTRIBUTION: Sagami Bay and above localities.

59. *Crangon communis* RATHBUN.

RATHBUN, 1899, p. 556; 1904, p. 123, Fig. 64.
Crago communis, SCHMITT, 1921, p. 95, *Fig.* 63.

LOC. Station 47, south of Todo-saki, 355 m. deep. July 10, 1926, 3 males and 1 female.

Station 51, east of Todo-saki, 344 m. deep. July 16, 1926. 1 male and 1 female.

Station 73, south of Siriya-zaki, 390 m. deep. July 28, 1926. 2 males and 1 female.

Station 577, north-east of Noto, 311 m. deep. July 28, 1930. 1 male.

Station 589, entrance of Toyama Bay, 326 m. deep. August 2, 1930. 1 male.

Station 591, off western Niigata-ken, 311 m. deep. August 3, 1930. 1 male.

DISTRIBUTION: From Bering Sea to Sandiego, California, 20–306 fathoms. Kamtchatca, 96–100 fathoms. From Japanese waters it has not hitherto been known.

60. ? *Crangon abyssorum* RATHBUN.

(Text-fig. 14.)

RATHBUN, 1902, p. 890; 1904, p. 125, Fig. 66.
Crago abyssorum, SCHMITT, 1921, p. 97.

LOC. *Station 247, east of Sikoku, 128–159 m. deep. November*

8, 1927. 2 males and 1 female.

Station 253, Sagami Bay, 452 m. deep. November 9, 1927. 1 male.

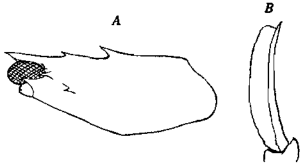
Station 260, Sagami Bay, 393 m. deep. November 15, 1927. 2 young specimens.

Station 268, south of Simoda, 547 m. deep. November 18, 1927. 1 male and 1 egg-bearing female.

Station 406, near middle between Kôti and Asizuri-zaki, 97 m. deep. December 7, 1928. 1 male.

The specimens referable to this species in nearly all respects with the description and the figures given by the author, differs in the following points:

The antennal scale is somewhat longer; the rostrum scarcely flattened above, and is somewhat longer.



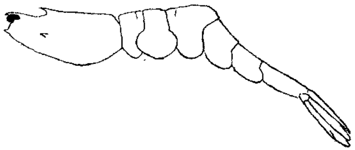
Text-fig. 14. *Crangon abyssorum*, RATHBUN.
A, Carapace (×6). *B*, Scaphocerite (×6).

61. *Crangon geniculata* n. sp.

(Text-fig. 15.)

LOC. Station 213, Kii Strait, 353 m. deep. July 18, 1927. 1 probably male.

Carapace carinated anterior four-fifths in the middle line, with a tooth at anterior one-third of this carina. Rostrum longer than eye, flattened above. Abdomen laterally compressed; anterior two somites dorsally rounded, but in third posterior half obtusely carinated, and abdomen strongly geniculated at the somite; two succeeding somites are also obtusely carinated. The sixth somite is provided with two longitudinal carinae on the dorsal aspect. The



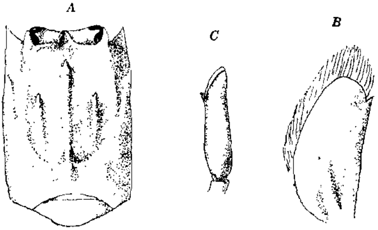
Text-fig. 15. *Crangon geniculata* n. sp. (×5)

telson is a little longer than the sixth abdominal somite.

62. *Crangon laevis* n. sp.

(Text-fig. 16.)

LOC. *Station 638, west of Tubaki-zaki, Aomori-ken, 73 m. deep.* August 18, 1930. 1 female.



Text-fig. 16. *Crangon laevis* n. sp.
A, Carapace, dorsal aspect (×5). *B*, Scaphocerite (×5). *C*, Chela (×5).

Near *Crangon munita* DANA[1]. Abdomen dorsally smooth and rounded; no median carina on fifth nor two on the sixth somite, but telson distinctly with a longitudinal furrow. In other respects it agrees with the description and figures given by investigators. Scaphocerite a little broader than one-half the length at the outer margin, and distally rounded. Chela nearly three and a half times as long as broad at the broadest point.

63. *Crangon longirostris* n. sp.

(Text-fig. 17.)

LOC. Station 381, east of Owase, Mie-ken, 329 m. deep. December 3, 1927. 1 male and 2 egg-bearing females.

Near *Crangon variabilis* RATHBUN[2]. Anterior two abdominal somites dorsally rounded, following three somites carinated in the middle line. Carapace shorter than half of the abdomen. Rostrum

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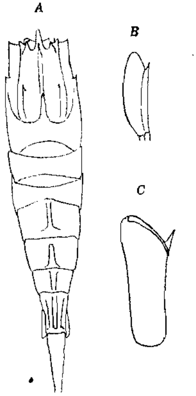
1) DANA, 1852, p. 536; 1855, Pl. 33, Fig. 5; RATHBUN, 1904, p. 127, Fig. 67.
2) RATHBUN, 1902, p. 890; 1904, p. 129, Fig. 69.

long, terminally rounded and longitudinally sulcated on the dorsal aspect, but at the base of the rostrum a small carina is just in front of anterior median tooth; other teeth on the carapace are similarly arranged as those of *Crangon variabilis.* Antennal scale, measuring along the outer margin, one-third as long as the carapace including rostrum. Chela three times as wide as long.



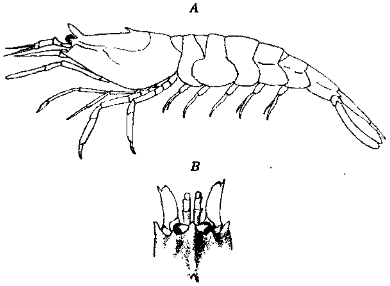
Text-fig. 17. *Crangon longirostris* n. sp.
A, Entire animal, dorsal aspect (×2). *B*, Scaphocerite (×2). *C*, Chela (×4).

64. ***Crangon trigonorostris*** n. sp.

(Text-fig. 18.)

Loc. Station 73, south of Siwoya-zaki, 390 m. deep. July 28, 1926. 1 probably female.

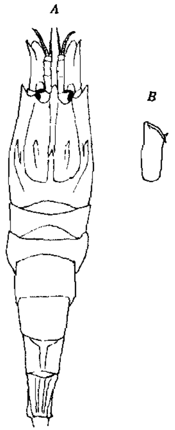
Body rather robust. Rostrum broad at the base, terminally obtusely pointed, triangular, ascending at an angle of about fourty-five degrees with the general level of the carapace. About anterior



Text-fig. 18. *Crangon trigonorostris* n. sp.
A, Entire animal, view from left side (×2).
B, Antennal part of carapace, dorsal aspect (×2).

three-fourths of the carapace obtusely carinated in the medial line, this carina is provided with one tooth; no hepatic tooth, but an antennal and a pterygostomian tooth. Eye of moderate size, longer than rostrum. Antennal scale nearly one half as long as carapace; spine exceeds blade. External maxilliped exceeds the antennal scale. Cheliped missing in the specimen. Second and third leg slender, but succeeding two pairs moderately stout.

The first three abdominal somites are dorsally rounded; the fourth and the fifth are dorsally obtusely carinated; sixth with a paired obtuse carinae. This somite and the telson are sulcated in the middle line. One or two carinae are on the lateral plates of the fourth, the fifth and sixth somites.



Text-fig. 19. *Crangon nipponensis* n. sp. *A*, Entire animal, dorsal aspect (×2). *B*, Chela (×2).

64. Crangon nipponensis n. sp.

(Text-fig. 19.)

LOC. *Station 22, east of Siwoya-zaki,* 539 m. deep. June 29, 1926. 1 female.

Near preceding two species. First lateral carina of carapace terminates in a point. A hepatic tooth. Rostrum longer than that of *C. trigonorostris*, not broad at the base; the lateral margins nearly parallel in dorsal view. Anterior four abdominal somites dorsally rounded. Antennal scale, in which outer spine exceeds the blade, one half as long as carapace excluding rostrum. Palm of chela two and a half times as long as wide.

Genus NECTOCRANGON BRANDT.

66. Nectocrangon lar (OWEN).

Crangon lar, OWEN, 1839, p. 88, Pl. 28, Fig. 1.
Argis lar, KRÖYER, 1842, p. 255, Pl. 5, Figs. 45–62.
Nectocrangon lar, STIMPSON, 1860, p. 25; ORTMANN, 1905, p. 137, Figs. 74, 75; RATHBUN, 1904, p. 137, Figs. 74, 75; BALSS, 1914, p. 67.

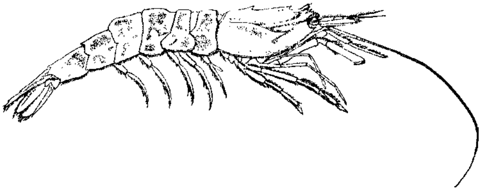
LOC. Station 578, east of Noto, 187 m. deep. July 28, 1930. 1 young specimen.
Station 611, east of Is. Sado, 143 m. deep. August 13, 1930. 1 female.

DISTRIBUTION: Circumpolar: Arctic coast of Alaska and Siberia; Greenland; Bering Sea; Kurile Islands. From Japan it has not been recorded, but in the north-western coast of Honsyû it is not rare. I have collected some specimens, in which there are some egg-bearing females in winter.

67. *Nectocrangon toyamaensis* n. sp.

(Text-fig. 20.)

LOC. Station 591, Toyama Bay, 311 m. deep. August 3, 1930. 1 male.



Text-fig. 20. *Nectocrangon toyamaensis n. sp.* (×2/3)

Integument thin, not much calcified as the preceding species, and it is hairy and traversed with keels and ridges. In the preceding species, the surface is nearly naked and almost smooth. The rostrum is a little ascending. In the two teeth on the median keel of the carapace, the posterior one is a little behind the middle between the anterior tooth and the posterior margin of the carapace, while in the preceding species it is in the middle. There is a rather conspicuous ridge, running between the hepatic tooth and the posterior margin of the carapace. The telson is a little longer than the sixth pair of pleopoda.

In the male, the thoracic sterna have three spines in the medial line. I have examined some other specimens of this species, collected at Namerikawa, Toyama-ken. Examining these specimens the female

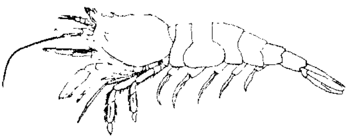
has the thoracic sterna with a sharply pointed spine directed forwards between the second pereiopoda, and the two succeeding spines, low and blunt. The abdominal sterna have no spines.

68. *Nectocrangon sadoensis* n. sp.

(Text-fig. 21.)

LOC. Station 600, north of Is. Sado, 168 m. deep. August 9, 1930. 1 female.

Body robust, hairy surfaced. Front obliquely elevated; rostral horn prominent, longer than lateral two lobes. Carapace obtusely carinated in the medial line, with four medial teeth or tubercles besides a hepatic tooth on each side; a tubercle just behind the rostral horn, the next is the most prominent, posterior two spinular tubercles are in subequidistance. First abdominal somite dorsally rounded; from second to fifth somites dorsally carinated in the middle line; paired carina of the sixth somite disappear near the posterior margin. The telson is also furnished with paired carinae, and on the posterior half there are two pairs of spinules. Tubercle on the inner extremity of the eye pointed. Proximal peduncular joint of the first antenna is nearly as long as the eye. External maxilliped exceeds the extremity of the scaphocerite. Chela of first leg nearly three times as wide as long. Second leg shorter than third, but longer than first. Posterior two pairs of leg similar shaped; terminal two segments compressed; fourth longer than fifth.



Text-fig. 21. *Nectocrangon sadoensis* n. sp. Natural size.

Genus SCLEROCRANGON SARS.

69. *Sclerocrangon angusticauda* (DE HAAN).

Crangon angusticauda, DE HAAN, 1849, p. 183, Pl. 45, Fig. 15; STIMPSON, 1860, p. 28.
Sclerocrangon angusticauda, ORTMANN, 1890, p. 533; DE MAN, 1907, p. 408.

LOC. Station 133, north of Inuboe-zaki, 33 m. deep. March 18,

1927. 1 male.

DISTRIBUTION: Japan: Hakodate, Simoda, Tokyo Bay, Sagami Bay, Nagasaki and above locality.

70. Sclerocrangon gasuyebi n. sp.

(Text-fig. 22.)

LOC. Station 602, north of Is. Sado, 205 m. deep. August 9, 1930. 1 female.

Station 628, south-west of Oga, 148 m. deep. August 17, 1930. 1 male.

Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 1 young specimen.

Text-fig. 22. *Sclerocrangon gasuyebi* n. sp. (×2/3).

Body is robust, nearly naked, sharply keeled and rich in sculptures. The exoskeleton is thick. The carapace is nearly as wide as long excluding the rostrum, the proximal half of which is broad, convex on the eye and provided with paired shallow longitudinal grooves, while the terminal half is subconical, ends in a point and is provided with a downwards directing process on the inferior margin. On the medial carina of the carapace, there are two teeth and two tubercles, the latter two are on the gastric region, and sometimes they are very insignificant, while the former two are on the cardiac region and prominent. The carapace is dilated antero-externally to a point and the frontal margin is concave as usual in the case of the species of this genus. On this frontal margin there is an extraorbital tooth, from which arising an obtuse ridge is continuous to the hepatic tooth. The lateral surface of the carapace is nearly vertical and provided with three longitudinal ridges, of which the upper two are arising from the hepatic tooth, the superior one runs backwards almost straightly to the posterior margin of the carapace, the other inferior one curving obliquely downwards and upwards ends at the posterior margin below the superior one.

The third lateral carina arising from the antero-lateral corner of the carapace runs backwards along the lateral inferior margin. Another obtuse carina continuous from the rostral margin, disappears near the middle of the said superior lateral carina.

In the abdomen, five anterior somites carinate in the middle line, and the sixth somite is provided with a paired carina. The telson is dorsally almost flat and three longitudinal shallow furrows are on the surface. Two pairs of marginal spinules are on the posterior half of the telson. Pleura are provided with two points in the anterior three, while those of the succeeding two abdominal somites are three pointed.

In the first antenna, the stylocerite is pointed and does not reach the distal end of the proximal peduncular article. The scaphocerite of the second antenna almost reaches the end of the flagellum of the first antenna, and the blade exceeds the outer spine. The outer maxilliped exceeds the end of the scaphocerite by more than half the length of its distal joint. First leg stout, chela about one and two-thirds as wide as long. Succeeding two legs slender, nearly equal in length.

The species is not rare on the coast of Toyama Bay and Niigata-ken, and known by the name of "Gasu-yebi".

Genus **PARACRANGON** DANA.

71. Paracrangon echinata DANA.

Paracrangon echinatus, DANA, 1852, p. 538; 1855, Pl. 33, Fig. 6.
Paracrangon echinata, RATHBUN, 1904, p. 143; BALSS, 1914, p. 72; SCHMITT, 1921, p. 103.

LOC. Station 58, north-east of Todo-saki, 177 m. deep. July 18, 1926. 5 males and 4 females.

Station 90, north of Todo-saki, 152 m. deep. November 3, 1926. 1 male.

Station 481, east of Fusan, Corea, 143 m. deep. August 8, 1929. 2 males.

Station, 541, north of Kyôga-saki, 150 m. deep. August 25, 1929. 1 female.

Station 611, east of Is. Sado, 143 m. deep. August 13, 1930. 1 male.

Station 618, off the mouth of Mogami River, 135 m. deep. August 14, 1930. 1 male.

DISTRIBUTION: Port Etches, Alaska to off La Jolla, California; Japan: Hokkaido, Sagami Bay and above localities.

Genus AEGEON GUÉRIN MÉNEVILLE.

72. *Aegeon obsoletum* BALSS.

BALSS, 1914, p. 70, Pl. 1, Fig. 3.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 26 specimens.

Station 409, coast of Kôti-ken, 77 m. deep. December 7, 1928. 1 female.

Station 531, near middle between Mihonoseki and Is. Oki, 86 m. deep. August 23, 1929. 1 male.

DISTRIBUTION: Japan: Sagami Bay and above localities.

73. *Aegeon habereri* (DOFLEIN).

Pontocaris habereri, DOFLEIN, 1902, p. 620, Pl. 1, Figs. 3, 4.
Aegeon habereri, RATHBUN, 1906, p. 911.
Aegeon (Pontocaris) habereri, BALSS, 1914, p. 71.

LOC. Station 353, near Tanabe, Wakayama-ken, 192 m. deep. August 4, 1928. 1 male.

Station 370, south of Atumi, Aiti-ken, 91 m. deep. August 10, 1928. 1 male.

Station 465, north of Is. Gotô, west of Hirato, 106 m. deep. July 24, 1929. 1 male and 1 egg-bearing female.

Station 471, north-west of Nagato, Yamaguti-ken, 90 m. deep. August 18, 1929. 1 male.

Station 503, near Is. Oki, 146 m. deep. August 18, 1929. 1 male.

DISTRIBUTION: Hawaii; Japan: Sagami Bay and above localities.

Genus PRIONOCRANGON WOOD-MASON.

74. *Prionocrangon dofleini* BALSS.

BALSS, 1913, p. 238; 1914, p. 71, Fig. 42.

LOC. Station 200, south of Toba, Mie-ken, 355 m. deep. July

11, 1927. 1 male.

The specimen coincides with the description and the figure given by BALSS, but teeth on the medial carina of the carapace are eight in number. When the distinction between the two species, *Prionocrangon ommatosteres* and *P. dofleini*, depends only on the number of the medial teeth, the present specimen is a intermediate one and both species may be nothing but a synonym.

DISTRIBUTION: Japan: Sagami Bay and above locality.

TRIBE STENOPIDEA.

Family **Stenopidae** BATE.

Genus **SPONGICOLA** DE HAAN.

75. ***Spongicola venusta*** DE HAAN.

DE HAAN, 1849, p. 194, Pl. 46, Fig. 9; MIERS, 1877, p. 507, Pl. 24, Figs. 1, 2; BATE, 1888, p. 213, Pl. 29; ORTMANN, 1890, p. 539; DOFLEIN, 1902, p. 642; BALSS, 1914, p. 74.

LOC. Station 307, east of southern Miyazaki-ken, 165 m. deep. July 14, 1928. 1 male.

DISTRIBUTION: Japan: Sagami Bay and above locality; Philippine Islands; Cebu.

TRIBE ERYONIDEA.

Family **Eryonidae** DE HAAN.

Genus **POLYCHELES** HELLER.

76. ***Polycheles amemiyai*** n. sp.[1]

(Text-fig. 23.)

LOC. Station 321, Bungo Strait, 457 m. deep. July 16, 1928. 1 female.

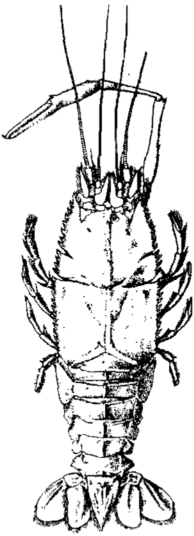
Near *Polycheles snyderi* RATHBUN[2]. Carapace oblong, wider than two-thirds the length of carapace, widest at a little behind the cervical groove; the length equaling the abdomen less half the telson. Frontal margin rather convex; with paired teeth on the middle and

[1] In honour of Prof. IKUSAKU AMEMIYA.

[2] RATHBUN, 1006, p. 898, Pl. 24, Fig. 9.

two on each side. Orbital notches deep, its outer margin continuous to the antero-external angle of the carapace; a pointed tooth on frontal margin of eye-stalk. Lateral margin of carapace serrated; eight teeth in front of the first sinus, four between the sinus and the cervical groove, and behind the groove there are fifteen teeth, of which posterior three very small. Median carina double, spinulous, with five in front of cervical groove, just behind which are paired spinules and other paired ones near the posterior margin of the carapace. On either side of the gastric region there is one spinule.

First to fifth abdominal terga are carinated in the middle line, the carinae of the anterior four are pointed forwards. Near the posterior margin of the sixth abdominal somite and at the base of the telson, each provided with a tubercle in the middle line. The inner expansion of the basal peduncular joint of the first antenna pointing terminally, is large, almost reaches the level of the end of the second antennal scale and is a little shorter than one-fourth the length of the carapace. External maxilliped barely reaching end of peduncle of the first antenna, is furnished with an epipodite. First leg (left one missing in the specimen) nearly as long as body; arm and palm with a distal spine above, but wrist unarmed. Some numbers of spinular teeth on both margins of the merus and the palm. Chela longer than merus, carpus longer than finger, which is a little longer than the palm. Second to fifth pairs of legs, all furnished with distinct chela, gradually diminishing in length and in stoutness, the second longer than one-third of the first.



Text-fig. 23. *Polycheles amemiyai* n. sp. (×2/3)

Occurence of this species is much noteworthy, as no one of Erionidian has been reported from Japanese waters.

TRIBE LORICATA.

Family **Scyllaridae** GRAY.

Genus **ARCTUS** DANA.

77. Arctus cultrifer ORTMANN.

Scyllarus arctus, FABR. *var.* DE HAAN, 1849, p. 154.
Arctus sordidus, BATE, 1888, p. 66, Pl. 9, Fig. 3.
Arctus haani, ORTMANN, 1891, p. 42.
Arctus cultrifer, ORTMANN, 1897, p. 272.
Scyllarus cultrifer, BALSS, 1914, p. 80.

LOC. Station 109, south-east of Inuboe-zaki, 123 m. deep. March 2, 1927. 1 male.
Station 271, west of Suno-saki, 82 m. deep. November 18, 1927. 1 male and 1 female.
Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 1 male.
Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 female.
Station 294, north of Is. Tanegasima, 102 m. deep. July 10, 1928. males.
Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 1 female.

DISTRIBUTION: Japan: Tokyo Bay and above localities; Ki Islands; Arafura Sea.

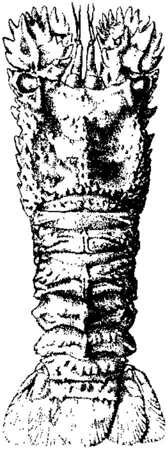
78. Arctus rugosus n. sp.

(Text-fig. 24.)

LOC. Station 300, southern Bungo Strait, 110 m. deep. July 11, 1928. 1 male.

Carapace quadrate, broader than long. Median crest formed by a double line of tubercles and divided into four sections, the anterior or rostral, the gastric, the cardiac and the post-cardiac. The gastric rises much higher anteriorly than the rostral, and the cardiac higher than the gastric. Between the latter two sections there is a cervical sulcus, which is continued to a deep depression on each side of the gastric section. The post-cardiac section is continuous from the cardiac, and interrupted by two transverse ridges. Along the lateral

margin, commencing with the inner canthus of the orbits, a longitudinal ridge formed of strong tubercles extends to the posterior margin, being bisected by the deep cutting of the cervical sulcus a short distance behind the orbits. The outer or branchial region of the carapace is strongly marked with anteriorly directed tubercles, placed in longitudinal rows.


Text-fig. 24. *Arctus rugosus* n. sp. (×2)

The pleon is marked by a tuberculated ridge that traverses the median line, reaching its highest level at the third somite, but the ridge is not so prominent as that of *Arctus tuberculatus* BATE[1] and is rather flattened above; there is no central ridge on the sixth somite. The first somite is smooth in the middle, being all but posterior margin in the middle, covered by the margin of the carapace when extended. Succeeding abdominal somites are strongly tuberculated on each side of the median ridges. The sixth somite and the anterior half of the telson are tuberculated.

The eyes are implanted in circular orbits fringed with small cilia. The first antenna is slender and its peduncle reaches the level of the distal end of the second antenna, when it straightly extends. The second antenna has the terminal joint fringed with seven prominent cusps, the smallest of which is on the inner margin, the others on the anterior. The penultimate is small and narrow, while the next is broad and diagonally produced as far as just behind the outer cusp of the terminal joint. This prominent angle of the second joint is continuous with a strong ridge that extends to the base and separates the joint into two divisions, the outer of which is depressed, and has the margin fringed with four strong cusps.

The first pair of pereiopoda is simple in form, short and robust. The four succeeding pairs are subequal, moderately long and rather

1) BATE, 1888, p. 70, Pl. 10, Figs. 1, 2.

slender; anterior pair has longer dactylus.

The species is nearly allied with *Arctus tuberculatus* BATE, but is distinguishable in the following points:

Carapace distinctly broader than long. Cervical sulcus is strongly depressed on each side of the median gastric crest. Median ridges of the abdominal somites are rather less prominent, but the lateral tubercles are stronger. Peduncle of first antenna not longer than second antenna, that has somewhat broader joints.

Genus **IBACUS** LEACH.

79. Ibacus ciliata (V. SIEBOLD).

DE HAAN, 1849, p. 153, Pls. 36, 37, Fig. 2; ORTMANN, 1890, p. 45; DOFLEIN, 1902, p. 643; BALSS, 1914, p. 80.

LOC. Station 387, south of Maisaka, Sizuoka-ken, 189–252 m. deep. December 11, 1927. 1 male.
Station 388, south of Maisaka, Sizuoka-ken, 133–189 m. deep. December 12, 1927. 1 male.
Station 398, near Owase, Mie-ken, 91 m. deep. February 29, 1928. 1 female.
Station 411, west of Kagosima-ken, 121 m. deep. April 25, 1928. 1 male.
Station 406, south of Kôti, 97 m. deep. May 3, 1928. 1 male.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay and above localities. I have examined some specimens of this species from Formosa.

TRIBE NEPHLOPSIDEA.

Family **Nephlopsidae** STEBBING.

Genus **NEPHLOPS** LEACH.

80. Nephlops japonicus TAPP. CANETRI.

TAPPARONE-CANETRI, 1873, p. 325; ORTMANN, 1891, p. 6; 1897, p. 272; PARISI, 1917, p. 15, Fig. 4.

LOC. Mitani, Aiti-ken, market, December 3, 1927. 1 male.
Station 382, east of Owase, Mie-ken, 180 m. deep. December 4, 1927. 1 male and 1 female.

Station 383, east of Owase, Mie-ken, 353 m. deep. December 4, 1927. 1 male.

Station 386, off Lake Hamana-ko, 100 m. deep. December 11, 1927. 1 egg-bearing female.

Station 388, off Lake Hamana-ko, 136–189 m. deep. December 12, 1927. 1 egg-bearing female.

Station 400, east of Owase, Mie-ken, 379 m. deep. March 2, 1928. 1 female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Suruga Bay and above localities.

TRIBE THALASSINIDEA.

Family **Axiidae** BATE.

Genus **AXIUS** LEACH.

81. Axius habereri BALSS.

BALSS, 1913, p. 238; 1914, p. 85, Figs. 46, 47.

LOC. Station 121, south-east of Siwoya-zaki, 102 m. deep. 1 female.

Station 248, Sagami Bay, 170 m. deep. November 8, 1927. 1 male.

Station 477, south of Husan, Corea, 99 m. deep. July 28, 1929. 1 female.

DISTRIBUTION: Japan: Sagami Bay and above localities.

82. Axius soyoi n. sp.

(Text-fig. 25.)

LOC. Station 109, south-east of Inuboe-zaki, 123 m. deep. May 2, 1927. 1 young specimen.

Station 120, south of Siwoya-zaki, 141 m. deep. March 4, 1927. 1 male.

Station 143, east of Siwoya-zaki, 132 m. deep. November 30, 1925. 1 male and 3 females.

Station 146, east of Siwoya-zaki, 201 m. deep. November 30, 1925. 1 male.

Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1

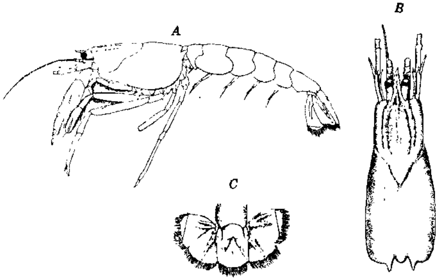
male.

Station 418, south of Satuma, Kagosima-ken, 133 m. deep. July 14, 1929. 1 female.

Station 461, east coast of Is. Tusima, 120 m. deep. July 24, 1929. 1 young specimen.

Near preceding species, but it differs in the following points:

Rostrum narrower at base and the lateral margins almost parallel. Five carinae on the gastric region; outer carina continuous to



Text-fig. 25. *Axius soyoi* n. sp.
A, Entire animal, view from left side (×3). *B*, Carapace, dorsal aspect (×5). *C*, Rhypidura, dorsal aspect (×3).

the lateral margin of the rostrum and provided with six teeth. Inner lateral carina as that of the preceding species, with about seven teeth. Median carina obtuse; provided with no tooth or tubercle. Behind cervical groove the median carina is very obscure. The basal joint of the first antenna is not dilated outwards. In the second antenna, the basal joint is short, while the next is long and longitudinally sulcated on the inner surface, terminating into two points, and the scale of pretty length is articulated at the outer corner. The succeeding two peduncular joints are cylindrical and longer, proximal one is nearly as long as the preceding or the second joint.

The antepenultimate joint of the third maxilliped has two or three spinules on the lower margin. In the pereiopods the anterior two pairs are chelate. The first of the right side (the left one unfortunately missing in all the specimens before me) exceeds the base

of the rostrum by the length of the terminal three joints; the merus is provided with granular teeth on the lower margin; carpus short; chela laterally compressed, upper half of palm granular; finger a little shorter than palm, granular near the upper margin and finely serrated at the inner margin. Posterior three legs simple; third almost reaches end of first; fourth somewhat more slender than the preceding; the last still more slender.

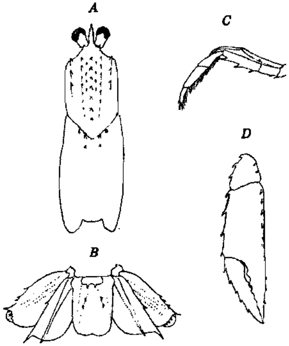
Posterior margin of telson less rounded than that of the preceding species, the spine on it less in number. Uropod with no spinules on the outer margin.

83. *Axius miyazakiensis* n. sp.

(Text-fig. 26.)

LOC. Station 305, east of southern Miyazaki-ken, 137 m. deep. July 12, 1928. 1 female.

Rostrum narrow, longer than eye, with two marginal teeth. A supraocular tooth. Anterior half of carapace with five carinae, a median and two lateral. The median carina with seven spinules; the inner lateral carina behind the supra-orbital tooth with about eight spinules; between this and the median carina there is a longitudinal series of minute spinules. Outer lateral carina with three teeth. Behind the cervical groove, the carapace dorsally rounded; and there are three spinular teeth on each side, two just behind the cervical groove another behind the inner one.



Text-fig. 26. *Axius miyazakiensis* n. sp.
A, Carapace, dorsal aspect (×3).
B, Rhypidura, dorsal aspect (×3).
C, 3rd maxilliped (×3).
D, Chela of 1st leg (×4).

Eye rather stout. First antenna long flagellated, the flagella nearly as long as body. Peduncle of second antenna subcylindrical, flagellum missing. Third maxilliped with some

numbers of spinular teeth on the inferior margins of the proximal three joints, terminal three joints unarmed. Larger chela of left side with marginal spinular teeth; finger a little longer than palm; other legs missing in the specimen.

Telson subquadrate; with three spinular teeth on each side. Uropod similar with that of *Oxyrhynchaxius japonicus* PARISI[1], two plates project to a point at outer angle.

84. *Axius (Eiconaxius) farreae* ORTMANN.

Eiconaxius farreae, ORTMANN, 1891, p. 49, Pl. 1, Fig. 4.
Axius (Eiconaxius) farreae, BALSS, 1914, p. 88.

LOC. Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 female.
Station 435, south of Is. Gotô, 324 m. deep. July 18, 1929. 2 males and 1 egg-bearing female.

Carapace shorter than abdomen. Exognath of third maxilliped exceeds the middle of the merus of the endognath of this appendage. Larger chela stout. In other respects it strictly agrees with description of the author.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay and above localities.

Family **Callianassidae** BATE.

Genus **CALLIANASSA** LEACH.

85. *Callianassa substerranea japonica* ORTMANN.

Callianassa petalura, STIMPSON, 1860, p. 23.
Callianassa subterranea japonica, ORTMANN, 1892, p. 56, Pl. 1, Fig. 10; DOFLEIN, 1902, p. 644; BALSS, 1914, p. 91; YOKOYA, 1930, p. 543.

LOC. Station 417, southern coast of Satuma, Kagosima-ken, 192 m. deep. July 14, 1929. 2 males.
Station 617, off Honzyô, Akita-ken, 106 m. deep. August 14, 1930. 1 female.

DISTRIBUTION: Japan: Hakodate, Mutu Bay, Simoda, Bingo and above localities.

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1) PARISI, 1017, p. 18, Fig. 5.

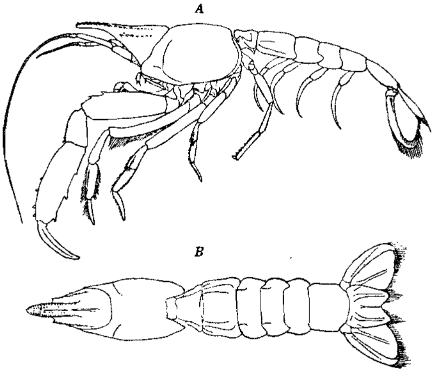
Genus **Upogebia** Leach.

86. Upogebia Kyusyuensis n. sp.

(Text-fig. 27.)

Loc. Station 305, east of southern Miyazaki-ken, 137 m. deep. July 12, 1929. 2 females, 1 bears eggs.
Station 417, south of Satuma, Kagosima-ken, 192 m. deep. July 14, 1929. 25 males and 10 egg-bearing females.
Station 418, south of Satuma, Kagosima-ken, 133 m. deep. July 14, 1929. 1 male and 1 egg-bearing female.
Station 465, north of Is. Gotô, 106 m. deep. July 24, 1929. 1 egg-bearing female.

Body rather slender. Carapace smooth behind the cervical groove. Before the cervical groove the carapace is lightly keeled in the medial line on the posterior half, while the anterior half is provided with median longitudinal groove and bestudded with setae. The rostrum, consisting of three lobes, the median one is long and longitudinally sulcated between the lateral ones, the dorsal surface



Text-fig. 27. *Upogebia kyusyuensis* n. sp.
A, Entire animal, view from left side (×2).
B, Entire animal, dorsal aspect (×2).

of the median lobe is provided with a series of spinular granules on each side, between these granules there are bundles of setae. In the abdominal somites, the first is short, the second distinctly longer than any of the succeeding three somites. The sixth somite and the telson are nearly as long as the second. The telson is deeply emarginated at the posterior margin. The anterior two abdominal somites and the telson are dorsally more or less carinated.

The eye-stalk is subconical and the cornea is on the summit. The peduncle of the first antenna is nearly as long as the rostrum and its flagella are nearly as long as the peduncle. The second antenna, in which the peduncle consists of five joints, is devoid of scale and is a little longer than the rostrum; the flagellum is as long as the abdomen including the telson.

The endognath of the third maxilliped consists of seven joints, when it extends forwards it reaches the distal end of the rostrum; the exognath does not reach the end of the ischium of the endognath. The first leg is long and stout; the merus is nearly smooth surfaced and the upper and the lower margins are armed with some small teeth. The carpus and the propodus are also provided with marginal teeth, and those on the lower margin are conspicuous; the surface is more or less provided with small teeth. The dactylus being two-thirds as long as propodus is longitudinally furrowed. The succeeding pairs of legs are successively diminishing in length to the posterior and the fifth is the shortest of all; the dactyli are rather long in the anterior pairs, but that of the fifth is very short.

The species is allied with *Upogebia major* (DE HAAN), but it distinctly differs in the following points:

The rostrum is more prominent, and the median lobe projects much more than the lateral lobe. In front of the cervical groove there is a blunt carina in the middle line. The anterior two abdominal somites are laterally carinated and the first is much smaller. The posterior margin of the telson is emarginated. The eye-stalk is conical. The first leg seems to be simple, as the tooth on the inferior margin of the propodus is small. The second leg is nearly as stout as the succeeding ones.

In a large male the body is about 25 mm. long.

Genus CTENOCHELES KISHINOUYE.

87. *Ctenocheles balssi* KISHINOUYE.

KISHINOUYE, 1926, p. 63, Fig. 1.

LOC. Station 542, Wakasa Bay, 119 m. deep. July 1930. 1 female.

DISTRIBUTION: Japan Sea: near Kasiwazaki, Niigata-ken and Wakasa Bay.

TRIBE GALATHEIDEA.

Family **Galatheidae** DANA.

Subfamily Galatheinae ORTMANN.

Genus GALATHEA FABRICIUS.

88. *Galathea acanthomera* STIMPSON.

STIMPSON, 1858, p. 252; 1907, p. 232; BALSS, 1913, p. 2, Fig. 1 (Cited other literature and synonyms.).

LOC. Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 1 male.
Station 324, south-west coast of Sikoku, 106 m. deep. July 21, 1928. 2 males.
Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 egg-bearing female.
Station 385, southern coast of Atumi, Aiti-ken, 18–23 m. deep. December 4, 1927. 1 egg-bearing female.
Station 469, north-east of Is. Iki, 91 m. deep. July 25, 1929. 1 male.
Station 524, coast of Tottori-ken, 88 m. deep. August 23, 1929. 2 males and 2 egg-bearing femals.

DISTRIBUTION: Japan: Bonin Islands, Tokyo Bay, Sagami Bay, Kagosima, Maizuru and above localities. Depth: Littoral to 200 m.

89. *Galathea integra* BENEDICT.

BENEDICT, 1903, p. 248; BALSS, 1913, p. 7, Fig. 4.

LOC. Off Siwoya, November 30, 1925. 1 egg-bearing female.
Station 9, south of Inuboe-zaki, 138 m. deep. June 22,

1926. 1 female.
Station 74, east coast of Aomori-ken, 219 m. deep. July 27, 1926. 1 male.
Station 239, near Misaki, Sagami Bay, 307 m. deep. November 6, 1927. 3 males and 1 egg-bearing female.
Station 266, Suruga Bay, 128 m. deep. November 18, 1927. 1 male.
Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 1 male.
Station 285, east of Omae-zaki, 71 m. deep. July 4, 1928. 1 broken specimen.
Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 1 male.
Station 294, north of Is. Tanega-sima, 102 m. deep. July 10, 1928. 1 male.
Station 301, east of Kagosima-ken, 181 m. deep. July 12, 1928. 1 male.
Station 465, north of Is. Gotô, west of Hirato, 106 m. deep. August 22, 1929. 1 egg-bearing female.
Station 572, north of Noto, 132 m. deep. July 27, 1930. 1 female.
Station 637, north of Oga, 145 m. deep. August 18, 1930. 1 male and 1 egg-bearing female.
Station 645, west of Aomori-ken, 115 m. deep. August 22, 1930. 2 males.
Station 646, west of Tugaru Strait, 123 m. deep. August 22, 1930. 1 male and 1 female.
Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 1 female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay and above localites. Depth: 71–307 m.

90. Galathea multilineata BALSS.

BALSS, 1913, p. 9, Fig. 6.

LOC. Station 228, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 male.

DISTRIBUTION: Japan: Sagami Bay and above locality. Depth: 120 or 210 m.

91. *Galathea latirostris* DANA.

DANA, 1852, p. 480, Pl. 30, Fig. 8; BALSS, 1913, p. 10, Figs. 9, 10.

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 1 male.
Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 1 egg-bearing female.
Station 299, east of Kagosima-ken, 115 m. deep. July 11, 1928. 1 female.
Station 317, coast of Miyazaki-ken, 97 m. deep. July 16, 1928. 1 male.
Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 1 egg-bearing female.
Station 385, southern coast of Atumi, Aiti-ken, 18–23 m. deep. December 4, 1927. 1 egg-bearing female.
Station 465, near middle between Is. Iki and Is. Gotô, 106 m. deep. July 24, 1927. 2 egg-bearing females.

DISTRIBUTION: Fiji Islands; Bonin Islands. From Japanese waters it has not been known.

92. *Galathea pubescens* STIMPSON.

STIMPSON, 1858, p. 252; 1907, p. 233; BALSS, 1913, p. 11, Figs. 11, 12.

LOC. Station 220, west of Muroto-zaki, 234 m. deep. July 19, 1927. 1 male.

DISTRIBUTION: Ousima, Sagami Bay, Hakodate and above locality.

93. *Galathea australiensis* STIMPSON.

STIMPSON, 1858, p. 252; 1907, p. 233; HENDERSON, 1838, p. 118, Pl. 12, Fig. 5; HASWELL, 1882, p. 161; BALSS, 1913, p. 13, Fig. 13.

LOC. Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1 male and 1 egg-bearing female.
Station 467, south-east of Is. Tusima, 110 m. deep. July 25, 1929. 1 egg-bearing female.

Cheliped more slender than that in the figure given by BALSS.

DISTRIBUTION: Port Jackson; Arafura Sea; Japan: Sagami Bay and above localities.

94. *Galathea subsquamata* STIMPSON.

STIMPSON, 1858, p. 252; 1907, p. 233; HENDERSON, 1888, p. 118, Pl. 12, Fig. 4.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 1 female.

DISTRIBUTION: Philippine Islands; Japan: Ousima and above locality.

Genus MUNIDA LEACH.

95. *Munida japonica* STIMPSON.

STIMPSON, 1858, p. 252; 1907, p. 235; MIERS, 1879, p. 51; ORTMANN, 1892, p. 254; BORRADAILE, 1900, p. 422; DOFLEIN, 1902, p. 644; DE MAN, 1902, p. 724; BALSS, 1913, p. 15, Fig. 14.
Munida japonica heteracantha, ORTMANN, 1892, p. 255; DOFLEIN, 1902, p. 644.
M. sagamiensis, DOFLEIN, 1902, p. 623.
M. honsuensis, BENEDICT, 1903, p. 262.

LOC. Station 9, south of Inuboe-zaki, 138 m. deep. June 22, 1926. 2 females.
Station 68, near middle between Siriya-zaki and Todo-saki, 179 m. deep. July 25, 1926. 1 male.
Station 76, south of Siriya-zaki, 128 m. deep. July 21, 1926. 1 female.
Station 80, south of Siwoya-zaki, 113 m. deep. November 1, 1926. 1 male and 1 egg-bearing female.
Station 188, south-east of Omae-zaki, 214 m. deep. June 30, 1927. 2 egg-bearing females.
Station 208, near Siwo-misaki, 219 m. deep. July 13, 1927. 1 male.
Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 male.
Statian 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 2 males and 2 females.
Station 212, near Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 1 female.
Station 220, west of Muroto-zaki, 234 m. deep. July 19, 1927. 2 egg-bearing females.
Station 221, north-west of Muroto-zaki, 209 m. deep. July

20, 1927. 1 male.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 female.

Station 228, near Asizuri-zaki, 201 m. deep. July 24, 1927. 1 male.

Station 229, south of Asizuri-zaki, 256 m. deep. July 27, 1927. 1 male.

Station 253, Sagami Bay, 452 m. deep. November 9, 1927. 1 male.

Station 259, Suruga Bay, 188 m. deep. November 15, 1927. 1 male.

Station 271, west of Sunosaki, 82 m. deep. November 18, 1927. 1 male.

Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 male.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male.

Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 1 male.

Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 1 male.

Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 egg-bearing female.

Station 294, north of Is. Tanegasima, 102 m. deep. July 10, 1928. 1 male.

Station 296, east of Is. Tanegasima, 219 m. deep. July 11, 1928. 1 male.

Station 300, east of Kagosima-ken, 110 m. deep. July 11, 1928. 3 males.

Station 311, east of Miyazaki-ken, 165 m. deep. July 15, 1928. 1 male.

Station 315, east of Miyazaki-ken, 421 m. deep. July 15, 1928. 1 male.

Station 318, Bungo Strait, 324 m. deep. July 16, 1928. 1 male.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 2 males.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 5 males and 9 females, 7 bear eggs.

Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 1 female.

Station 334, south of Asizuri-zaki, 91 m. deep. July 26, 1928. 1 male.

Station 337, north-east of Asizuri-zaki, 130 m. deep. July 26, 1928. 1 female.

Station 344, south of Muroto-zaki, 543 m. deep. July 29, 1928. 1 male.

Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1 male and 2 egg-bearing females.

Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 male.

Station 365, south-east coast of Mie-ken, 93 m. deep. August 10, 1928. 1 male.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 egg-bearing female.

Station 394, near Tanabe, Wakayama-ken, 76 m. deep. February 26, 1929. 1 male.

Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 1 egg-bearing female.

Station 413, near middle between Sata-misaki and Is. Yaku, 249 m. deep. July 13, 1929. 1 egg-bearing female.

Station 417, south of Satuma, Kagosima-ken, 122 m. deep. July 14, 1929. 1 male.

Station 420, south Is. Kosiki, 132 m. deep. July 15, 1929. 6 males.

Station 425, near Is. Kosiki, 300 m. deep. July 15, 1929. 1 egg-bearing female.

Station 428, near middle between Nagasaki and Is. Kosiki, 119 m. deep. July 16, 1929. 1 male and 1 egg-bearing female.

Station 431, south-east of Is. Gotô, 152 m. deep. July 16, 1929. 1 egg-bearing female.

Station 435, south of Is. Gotô, 324 m. deep. July 18, 1929. 1 male.

Station 438, south-west of Is. Gotô, 219 m. deep. July 19, 1929. 3 males and 5 females, 4 bear eggs.

Station 439, south-west of Is. Gotô, 155 m. deep. July 19, 1929. 1 egg-bearing female.

Station 440, south-west of Is. Gotô, 152 m. deep. July 19, 1929. 6 males and 2 egg-bearing females.
Station 444, south of Is. Gotô, 194 m. deep. July 20, 1929. 1 male and 2 egg-beariug females.
Station 446, west of Is. Gotô, 117 m. deep. July 20, 1929. 1 male and 1 egg-bearing female.
Station 447, near Is. Gotô, 90 m. deep. July 20, 1929. 1 male and 2 females.
Station 451, west of Is. Gotô, 187 m. deep. July 22, 1929. 1 male.
Station 462, south of Is. Tusima, 117 m. deep. July 24, 1929. 1 egg-bearing female.
Station 464, near middle between Is. Tusima and Gotô, 146 m. deep. July 24, 1929. 2 males.
Station 465, north of Is. Gotô, 106 m. deep. July 24, 1929. 2 males and 1 egg-bearing female.
Station 467, south-east of Is. Tusima, 110 m. deep. July 25, 1929. 1 male and 1 egg-bearing female.
Station 468, west of Is. Iki, 112 m. deep. July 25, 1929. 1 male.
Station 471, north-west of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 egg-bearing female.
Station 485, east Is. Misima, 93 m. deep. August 11, 1929. 1 female.
Station 542, Wakasa Bay, 119 m. deep. July 18, 1930. 3 males.
Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 male and 1 female.
Station 553, north of Mikuni, Hukui-ken, 113 m. deep. July 21, 1930. 1 egg-bearing female.
Station 568, north of Noto, 90 m. deep. July 27, 1930. 1 male and 3 females.
Station 572, north of Noto, 132 m. deep. July 27, 1930. 1 male and 5 young specimens.
Station 583, Toyama Bay, 110 m. deep. July 30, 1930. 1 male.
Station 584, Toyama Bay, 212 m. deep. July 30, 1930. 1 male.
Station 587, Toyama Bay, 97 m. deep. August 2, 1930. 2

egg-bearing females.

Station 588, Toyama Bay, 219 m. deep. August 2, 1930. 1 male and 1 broken specimen.

Station 591, western coast of Niigata-ken, 311 m. deep. August 3, 1930. 4 males and 1 female.

Station 594, north-west of Niigata, 72 m. deep. August 4, 1930. 3 males.

Station 595, south of Is. Sado, 145 m. deep. August 7, 1930. 1 male and 2 females.

Station 599, north of Is. Sado, 181 m. deep. August 9, 1930. 1 male.

Station 606, north of Is. Sado, 117 m. deep. August 10, 1930. 2 males and 1 female.

Station 617, off the mouth of Mogami River, 106 m. deep. August 14, 1930. 1 male and 2 females, 1 bears eggs.

Station 618, off the mouth of Mogami River, 135 m. deep. August 14, 1930. 3 males and 4 females, 3 bear eggs.

Station 620, off Yamagata-ken, 139 m. deep. August 15, 1930. 2 males and 1 egg-bearing female.

Station 627, south of Oga, 148 m. deep. August 17, 1930. 1 egg-bearing female.

Station 630, south of Oga, 150 m. deep. August 17, 1930. 1 male and 2 females, 1 bears eggs.

Station 636, north of Oga, 115 m. deep. August 18, 1930. 3 males and 1 female.

Station 637, north of Oga, 145 m. deep. August 18, 1930. 2 males and 1 female.

Station 638, west of Tubaki-zaki, Aomori-ken, 73 m. deep. August 18, 1930. 2 males and 5 females.

Station 640, near Tubaki-zaki, 179 m. deep. August 22, 1930. 1 male and 1 egg-bearing female.

Station 642, north of Tubaki-zaki, 364 m. deep. August 22, 1930. 1 female.

Station 643, west of northern Aomori-ken, 132 m. deep. August 22, 1930. 1 male.

Station 645, west of northern Aomori-ken, 115 m. deep. August 22, 1930. 33 males and 21 females, most bear eggs.

Station 646, west of northern Aomori-ken, 123 m. deep.

August 22, 1930. 2 males.
Station 647, west of northern Aomori-ken, 86 m. deep. August 23, 1930. 1 male.
Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 2 egg-bearing females.

As suggested by BALSS in 1913, numerous specimens before me show that *M. japonica heteracantha* as well as *M. sagamiensis* and *M. honsyuensis* are nothing but synonyms of the present species.

DISTRIBUTION: Japan: Sagami Bay, Kagosima Bay, Corea Strait and above localities. Talili Bay; New Britannia; Halmahera. Depth to 543 m.

96. *Munida andamanica* ALCOCK.

ALCOCK, 1901, p. 242, Illustration Investigator, Pl. 13, Fig. 2; BALSS, 1913, p. 17; DOFLEIN and BALSS, 1913, p. 143.
Munida curvatura, BENEDICT, 1903, p. 253.

LOC. Station 217, north-east of Muroto-kaki, 421 m. deep. July 19, 1927. 1 female.
Station 223, south of Kôti, 311 m. deep. July 20, 1927. 1 male.
Station 264, Suruga Bay, 280 m. deep. November 17, 1927. 2 females, 1 bears eggs.
Station 321, Bungo Strait, 457 m. deep. July 16, 1928. 1 male and 1 female.
Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 1 male.
Station 382, near Owase, Mie-ken, 180 m. deep. December 4, 1928. 1 male.
Station 383, east of Owase, Mie-ken, 353 m. deep. December 4, 1928. 3 males and 3 females.

DISTRIBUTION: Andaman Sea; Arabian Sea; east coast of Africa; near Sumatra; Japan: Sagami Bay and above localities.

97. *Munida scabra* HENDERSON.

HENDERSON, 1885, p. 409; 1888, p. 134, Pl. 15, Fig. 1.

LOC. Station 9, south of Inuboe-zaki, 138 m. deep. June 22, 1926. 1 egg-bearing female.

Station 255, Sagami Bay, 263 m. deep. November 10, 1927. 1 female.
Station 316, east of Miyazaki-ken, 190 m. deep. July 16, 1928. 1 male.
Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 male.
Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 1 male.
Station 435, south of Is. Gotô, 324 m. deep. July 18, 1929. 1 male.
Station 438, south-west of Is. Gotô, 219 m. deep. July 19, 1929. 1 male and 4 females.
Station 440, south-west of Is. Gotô, 152 m. deep. July 19, 1929. 1 male and 1 egg-bearing female.
Station 444, south of Is. Gotô, 194 m. deep. July 20, 1929. 1 male.
Station 449, north-west of Is. Gotô, 155 m. deep. July 22, 1929. 1 male and 1 female.
Station 451, west of Is. Gotô, 187 m. deep. July 22, 1929. 3 males.
Station 454, east of Is. Saisyûtô, 113 m. deep. July 23, 1929. 1 male.
Station 462, south of Is. Tusima, 117 m. deep. July 24, 1929. 1 male and 1 egg-bearing female.
Station 465, north of Is. Gotô, west of Hirato, 106 m. deep. July 25, 1929. 2 females.

The specimens strictly coincide with the description and the figure given by the author.

DISTRIBUTION: off Little Ki Island (140 fms.); from Japanese waters it has not been reported.

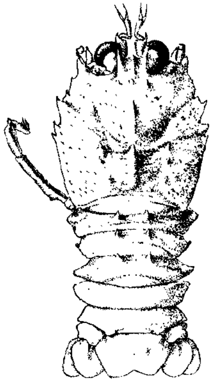
98. *Munida brevirostris* n. sp.

(Text-fig. 28.)

LOC. Station 465, north of Is. Gotô, 106 m. deep. July 24, 1929. 1 male.

This pecular species is easily distinguishable from other allied species.

The rostrum is very short, and is slightly indicated by a small projection in the middle between the supraorbital teeth. From this rostral projection a light keel is continued backwards in the middle line of the carapace. On the surface there are minute scales and teeth; two teeth in the middle line are prominent, one on the gastric and the other on the cardiac region. Just before the latter is the cervical groove, which is continuous to the notch on the lateral margin of the carapace. Behind the supraorbital tooth there is a small one and two somewhat larger teeth are on each side of the cardiac one. On the lateral margin there are three teeth hehind the extraorbital angle before the said lateral notch; in these three teeth the posterior one is much larger than the anterior two. Behind the lateral notch two teeth are on the margin.



Text-fig. 28. *Munida brevirostris* n. sp. (×5)

Each of the second, the third and the fourth abdominal somites is provided with a pair of teeth on the dorsal aspect.

Eye-stalk stout, cornea dilated. Basal peduncular joint of first antenna stout, longer than eye, produced to a point at the outer margin; distal two joints nearly as long as the proximal one and usually plicated. Peduncle of second antenna short, flagellum missing in the specimen. All pereiopods, but last one also missing in the specimen.

Genus CERVIMUNIDA BENEDICT.

99. *Cervimunida princeps* BENEDICT.

BENEDICT, 1903, p. 249; BOUVIER, 1906, p. 480; BALSS, 1913, p. 18, Pl. 1, Fig. 1, Text-fig. 15.

LOC. Mitani, Aiti-ken, market, December 3, 1927. 1 male.
Station 138, east of Kinkazan, 285 m. deep. November

24, 1925. 1 male.

Station 157, near Inuboe-zaki, 76 m. deep. November 9, 1926. 1 male and 1 egg-bearing female.

Station 159, north-east of Inuboe-zaki, 208 m. deep. November 13, 1926. 1 male.

Station 223, south of Kôti, 311 m. deep. July 20, 1927. 1 female.

Station 253, Sagami Bay, 452 m. deep. November 9, 1927. 1 male.

Station 255, near Simoda, 263 m. deep. November 10, 1927. 1 young specimen.

Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 3 males and 2 females.

Station 381, east of Owase, Mie-ken, 329 m. deep. December 3, 1927. 4 males and 2 females.

Station 382, east of Owase, Mie-ken, 180 m. deep. December 4, 1927. 4 males and 1 female.

Station 386, off the mouth of the River Tenryû, 100 m. deep. December 11, 1927. 2 males and 1 egg-bearing female.

Station 605, north of Is. Sado, 139 m. deep. August 10, 1930. 1 female.

Station 616, off Yamagata-ken, 106 m. deep. August 14, 1930. 1 male.

DISTRIBUTION: Japan: Sagami Bay and above localities. Depth between 76 m. and 452 m.

Subfamily Munidopsinae ORTMANN.

Genus **MUNIDOPSIS** WHITEAVES.

100. Mupidopsis trifida HENDERSON.

HENDERSON, 1888, p. 156, Pl. 16, Fig. 2; ALCOCK, 1901, p. 260; BENEDICT, 1903, p. 329; BALSS, 1913, p. 20.

LOC. Station 264, Suruga Bay, 280 m. deep. November 17, 1927. 1 male.

DISTRIBUTION: West of Patagonia; Bay of Bengal; Arabian Sea; Japan: Sagami Bay, Suruga Bay.

Family **Chirostylidae** ORTMANN.

Genus **EUMUNIDA** SMITH.

101. Eumunida smithii HENDERSON.

HENDERSON, 1888, p. 169, Pl. 15, Fig. 5; BALSS, 1913, p. 21, Figs. 16, 17.

LOC. Station 257, east of Simoda, 137 m. deep. November 10, 1927. 1 female.
Station 435, south Is. Gotô, 324 m. deep. July 18, 1929. 1 female.

In the specimen from Station 435, the supraorbital spine is distinctly longer than the rostral one.

DISTRIBUTION: Little Ki Island; Japan: Sagami Bay and above locality.

Genus **UROPTYCHUS** HENDERSON.

102. Uroptychus nitidus occidentalis FOXON.

FOXON, 1895, p. 101; BALSS, 1913, p. 27.

LOC. Station 223, south of Kôti, 311 m. deep. July 20, 1927. 2 females.
Station 233, Kurose Bank near Hatizyô, Isl. 198 m. deep. July 30, 1927. 1 female.
Station 261, Suruga Bay, 609 m. deep. November 15, 1927. 1 female.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male.
Station 309, east of Kagosima-ken, 472 m. deep. July 14, 1928. 1 male.
Station 335, east of Asizuri-zaki, 399 m. deep. July 26, 1928. 1 male.
Station 342, west of Muroto-zaki, 288–527 m. deep. July 28, 1928. 1 male.
Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 egg-bearing female.
Station 355, Kii Strait, 439 m. deep. August 4, 1928. 1 egg-bearing female.
Station 356, near Siwo-misaki, 384 m. deep. August 8, 1928. 1 egg-bearing female.

Station 367, south-east of Toba, Mie-ken, 291 m. deep. *August 10, 1928. 1 young female.*

Station 368, south of Atumi, Aiti-ken, 600 m. deep. August 10, 1928. 1 male.

Station 372, south of Lake Hamana, 466 m. deep. August 13, 1928. 1 female.

DISTRIBUTION: Panama; Japan: Sagami Bay and above localities. 91 m. is the most shallow in the known depth.

103. Uroptychus scandens BENEDICT.

BENEDICT, 1903, p. 298; BALSS, 1913, p. 27, Figs. 19, 20.

LOC. Station 103, east of Bôsyû, 117 m. deep. February 26, 1927. 1 female.

Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 1 female.

Station 319, Bungo Strait, 210 m. deep. July 16, 1928. 1 egg-bearing female.

Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 2 egg-bearing females.

DISTRIBUTION: Japan: near Sagami Bay and above localities. Depth: 110–393 m.

104. Uroptychus grandirostris n. sp.

(Text-fig. 29.)

LOC. Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1928. 2 egg-bearing females.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1928. 2 males and 1 egg-bearing female.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1928. 1 male.

Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 1 female.

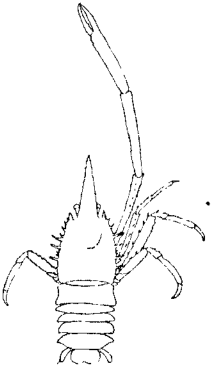
Station 429, south of Nagasaki, 223 m. deep. July 16, 1929. 1 male.

Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 1 male.

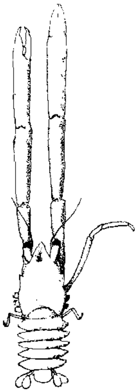
Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 1 egg-bearing female.

The new species is easily distinguishable from other species of this genus in the large rostrum, which is more than three times the length of the eye-stalk and its width is more than one third the width of the carapace excluding the lateral spine. These lateral spines are arranged like those of *Uroptychus spinimarginatus* HENDERSON[1]. In other respects the present species is nearly allied to this species, but it differs in the larger rostrum, in the narrower lateral spines and in the somewhat narrower carapace. The body is covered with short hairs, the rostrum is longitudinally sulcated and the gastric region of the carapace is somewhat convex.

Depth: 165–223 m.



Text-fig. 29. *Uroptychus grandirostris* n. sp. (×3)



Text-fig. 30. *Uroptychus latirostris* n. sp. (×2)

105. Uroptychus latirostris n. sp.

(Text-fig. 30.)

LOC. Station 330, near Asizuri-zaki, 102 m. deep. July 22, 1928. 1 egg-bearing female.

Carapace dorsally flat and smooth; rostrum broad triangular, its dorsal surface concave and nearly as long as eye. Lateral margin of the carapace with a broad but pointed tooth a little in front of the cervical groove. Chelipeds cylindrical and smoothly surfaced; the right one a little longer than the left.

[1] HENDERSON, 1888, p. 175, Pl. 21, Fig. 2.

Family **Porcellanidae** HENDERSON.

Genus **PETROLISTHES** STIMPSON.

106. Petrolisthes militaris (HELLER).

Porcellana militaris, HELLER, 1862, p. 523; DE MAN, 1887, p. 410.
Petrolisthes militaris, ORTMANN, 1892, p. 265.

LOC. Station 294, north of Tanegasima Isl., 102 m. deep. July 10, 1928. 1 egg-bearing female.

DISTRIBUTION: Nicobar Islands; Edam Isl.; Japan: Amami Ôsima; and above locality.

Genus **PORCELLANELLA** WHITE.

107. Porcellanella picta STIMPSON.

STIMPSON, 1858, p. 243; 1907, p. 193, Pl. 22, Fig. 6.

LOC. Station 384, near Toba, Mie-ken, 38–21 m. deep. December 4, 1927. 3 males and 1 egg-bearing female.

No marking on the carapace seen in the figure given by STIMPSON.

DISTRIBUTION: near Hongkong, China; from Japanese waters none has been reported.

TRIBE PAGURIDEA.

Family **Pylochelidae** BATE.

Genus **MIXTOPAGURUS** MILNE-EDWARDS.

108. Mixtopagurus spinosus (HENDERSON).

Pylocheles spinosus, HENDERSON, 1888, p. 101, Pl. 11, Fig. 1; ORTMANN, 1892, p. 274.
Mixtopagurus spinosus, BALSS, 1913, p. 34.

LOC. Station 239, Sagami Bay, 307 m. deep. November 6, 1927. 1 male.
Station 266, Suruga Bay, 128 m. deep. November 18, 1927. 1 egg-bearing female.
Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 1 male.

DISTRIBUTION: Twofold Bay, Australia; Japan: Tokyo Bay, Sagami Bay and Suruga Bay. Depth: 100–307 m.

109. Mixtopagurus jeffreysii (MIERS).

Pomatochelcs jeffreysii, MIERS, 1879, p. 49.
Mixtopagurus jeffreysii, BALSS, 1913, p. 35, Pl. 2, Fig. 1.

LOC. Station 267, Suruga Bay, 64 m. deep. July 2, 1928. 2 males.
Station 273, off Lake Hamana, 123 m. deep. July 2, 1928. 1 male and 1 female.
Station 276, west of Omae-zaki, 77 m. deep. July 2, 1928. 2 males.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male.
Station 283, between Omae-zaki and Irô-zaki, 177 m. deep. July 4, 1928. 1 male.
Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 2 males and 2 females.
Station 319, Bungo Strait, 210 m. deep. July 16, 1928. 4 males.
Station 325, west of Asizuri-zaki, 210 m. deep. July 21, 1928. 1 male.
Station 329, west of Asizuri-zaki, 296 m. deep. July 22, 1928. 1 male.
Station 353, near Tanabe, Wakayama-ken, 192 m. deep. August 4, 1928. 1 egg-bearing female.
Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 2 males.
Station 370, south of Atumi, Aiti-ken, 91 m. deep. August 10, 1928. 1 female.
Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 2 egg-bearing females.
Station 502, near Oki Isls., 110 m. deep. August 15, 1929. 1 egg-bearing female.

DISTRIBUTION: Japan: Sagami Bay and above localities. Depth: 34–350 m.

110. Mixtopagurus rigidus n. sp.

(Text-fig. 31.)

LOC. Station 189, south of Omae-zaki, 196 m. deep. July 1, 1927. 1 male.

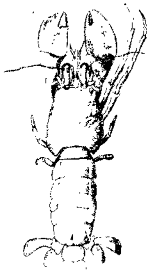
Station 293, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 1 egg-bearing female.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 egg-bearing female.

Station 364, east of Tanegasima Isl., 219 m. deep. July 11, 1928. 1 male.

Station 425, near Kosiki Isls., 300 m. deep. July 15, 1929. 1 male and 1 egg-bearing female.

Carapace calcified but near the lateral margin of posterior half. The frontal margin is provided with two pairs of small processes, rostrum wanted. Eye-stalk moderate in length and size; basal acicle small. Peduncle of first antenna longer than eye. Peduncle of second antenna shorter than eye; scale short and finely serrated, the outer margin as well as basal joint. First leg or chelipeds subequal; merus trigonal, smoothly surfaced and naked, one or two spinular teeth on each of ventral two keels; carpus with a strong transverse carina near the distal end, this carina carrying a series of spinules divides the dorsal surface of the carpus into two sections, the anterior is almost vertical surfaced and setose as well as the dorsal surface of the palm, while the posterior is smooth and naked, but there are a number of tubercular teeth. The palma is broad and its dorsal surface is nearly flat, setose and provided with some pointed teeth, while the ventral surface is moderately convex and nearly naked. Succeeding two pairs of legs similar in length and in shape; they are long and slender; carpus nearly as long as dactylus, a little shorter than propodus. Posterior two legs small; fourth not chelate nor furnished with rasp, while the fifth is subchelate and furnished with rasp.



Text-fig. 31. *Mixtopagurus rigidus* n. sp. Natural size.

Abdomen distinctly seven segmented; in each of second to sixth somites, tergum is distinguished from pleuron by a furrow and is dorsally rounded, but that of the sixth somite is dorsally notched in the middle line. The telson is divided into two sections, anterior and posterior; the former is rather thick and terminates in a point, while the latter is laminar and the posterior margin is notched in

the middle. Abdominal appendages biramose in both sexes. Sixth abdominal appendage is stout and the branches are furnished with rasp near the outer margins.

The egg is ellipsoid in shape, measuring about 1.8 × 1.2 mm.

Dimension of two specimens from Station 425:

Length of carapace	12.2 mm.	5.0 mm.
Length of abdomen	14 5	9.2
Width of abdomen at broadest point	11.0	4.8

Family **Paguridae** DANA.

Subfamily Pagurinae ORTMANN.

Genus **PAGURISTES** DANA.

111. Paguristes digitalis STIMPSON.

STIMPSON, 1858, p. 247; 1907, p. 212, Pl. 25, Fig. 1; BALSS, 1913, p. 37, Figs. 26, 27.

LOC. Station 79, near Siriya-zaki, 102 m. deep. November 1, 1926. 1 male.

Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 1 male and 1 female.

DISTRIBUTION: Japan: Hakodate, Sagami Bay and above localities. Depth: 20–150 m.

112. Paguristes pusillus HENDERSON.

HENDERSON, 1896, p. 526; ALCOCK, 1905, p. 37, Pl. 3, Fig. 3; BALSS, 1913, p. 40.

LOC. Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 male.

DISTRIBUTION: Ceylon; Gulf of Manaar; Japan: Sagami Bay and above locality.

113. Paguristes palithophilus ORTMANN.

ORTMANN, 1892, p. 277, Pl. 12, Fig. 5; DOFLEIN, 1902, p. 645; BALSS, 1913, p. 38.

LOC. Station 325, west of Asizuri-zaki, 210 m. deep. July 21, 1928. 1 egg-bearing female.

Station 445, west of Sata-misaki, Kagosima-ken, 219 m.

deep. July 13, 1929. 1 female.

Station 445, near Gotô Isls., 73 m. deep. July 20, 1929. 1 male.

Station 462, south of Tusima Isl., 117 m. deep. July 24, 1929. 1 male and 1 female.

Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 3 males.

DISTRIBUTION: Japan: Sagami Bay and above localities. Depth: *73–300 m.*

114. Paguristes acanthomerus ORTMANN.

ORTMANN, 1892, p. 279, Pl. 12, Fig. 6; DOFLEIN, 1902, p. 645; BALSS, 1913, p. 39.

LOC. Station 194, coast of Maisaka, Sizuoka-ken, 192 m. deep. July 4, 1927. 1 female.

Station 267, Suruga Bay, 64 m. deep. July 2, 1928. 2 males.

Station 273, off Lake Hamana, 123 m. deep. July 2, 1928. 1 female.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 2 males and 1 egg-bearing female.

Station 279, Suruga Bay, 155 m. deep. July 2, 1928. 1 male.

Station 283, between Omae-zaki and Irô-zaki, 177 m. deep. July 4, 1928. 1 male.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 male.

Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 2 females.

Station 410, between Kosiki Isls. and Satuma, Kagosima-ken, 139 m. deep. April 25, 1928. 1 male.

Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 1 male.

DISTRIBUTION: Sagami Bay, Tokyo Bay and above localities.

115. Paguristes barbatus (HELLER).

Clibanarius barbatus, HELLER, 1862, p. 524; 1865, p. 90, Pl. 7, Fig. 5.
Paguristes barbatus, ORTMANN, 1892, p. 279, Pl. 12, Fig. 7; BALSS, 1913, p. 39.

LOC. Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 2 egg-bearing females.

Station 289, near Lake Hamana, 84 m. deep. July 5, 1928. 1 female.

Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 1 male and 1 egg-bearing female.

Station 325, west of Asizuri-zaki, 210 m. deep. July 21, 1928. 1 egg-bearing female.

Station 330, near Asizuri-zaki, 102 m. deep. July 22, 1928. 1 female.

Station 471, north-west of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 female.

Station 572, north of Noto, 132 m. deep. July 27, 1930. 1 male.

DISTRIBUTION: Japan: Rikuzen, Tokyo Bay, Sagami Bay and bove localities. New Zealand.

116. Paguristes kagoshimensis ORTMANN.

ORTMANN, 1892, p. 281, Pl. 12, Fig. 8; BALSS, 1913, p. 40.

LOC. Station 179, near Irô-zaki, 187 m. deep. June 28, 1927. 1 egg-bearing female.

Station 189, south of Omae-zaki, 196 m. deep. July 1, 1927. 1 female.

Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 male and 2 females.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 male.

Station 276, Suruga Bay, 77 m. deep. July 2, 1928. 2 males and 1 female.

Station 293, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 1 female.

Station 295, north of Tanegasima Isl., 154 m. deep. July 11, 1928. 1 male and 1 egg-bearing female.

Station 296, east of Tanegasima Isl., 219 m. deep. July 11, 1928. 1 male.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 male and 3 egg-bearing females.

Station 322, west of Muroto-zaki, 110 m. deep. July 16,

1928. 1 male.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 male and 1 egg-bearing female.

Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 4 males.

Station 327, west of Asizuri-zaki, 276 m. deep. July 21, 1928. 1 male.

Station 329, west of Asizuri-zaki, 296 m. deep. July 22, 1928. 2 males.

Station 326, near Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 male.

Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 1 male and 1 female.

Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 2 males and 2 females, 1 bears eggs.

Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 6 males and 5 females, 3 bear eggs.

Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 1 male.

Station 439. south-west of Gotô Isls., 155 m. deep. July 19, 1929. 2 males.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

Station 447, near Gotô Isls., 90 m. deep. July 20, 1929. 1 male.

Station 459, west of Tusima Isl., 115 m. deep. July 23, 1929. 2 males.

Station 462, south of Tusima Isl., 117 m. deep. July 24, 1929. 1 male.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 3 males.

DISTRIBUTION: Japan: Sagami Bay, Kagosima and above localities.

117. Paguristes setosus (MILNE-EDWARDS).

ORTMANN, 1892, p. 281, Pl. 12, Fig. 9.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1 female.

Station 289, *east of* Omae-zaki, 84 m. deep. July 5, 1928. 1 male.

Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 male and 1 female.

Station 407, between Kôti and Asizuri-zaki, 100 m. deep. December 7, 1928. 1 male.

Station 468, east of Is. Tusima, 112 m. deep. July 25, 1929. 1 male.

Station 638, west of Tubaki-zaki, Aomori-ken, 73 m. deep. August 18, 1930. 1 male.

DISTRIBUTION: Neu-Guinea; Japan: Sagami Bay and above localities. Station 638 is an extraordinary northern distribution. Depth: 73–238 m.

Genus DIOGENES DANA.

118. Diogenes penicillatus STIMPSON.

STIMPSON, 1858, p. 246; 1907, p. 203.

LOC. Station 133, north of Inuboe-zaki, 33 m. deep. March 18, 1927. 1 male.

Station 323, Bungo Strait, 88 m. deep. July 21, 1928. 1 female.

DISTRIBUTION: Japan: east of Miyagi-ken and above localities. Depth: 33–88 m.

119. Diogenes edwardsii (DE HAAN).

Pagurus edwardsii, DE HAAN, 1849, p. 211, Pl. 50, Fig. 1.

Diogenes edwardsii, STIMPSON, 1858, p. 246; 1907, p. 202, Pl. 24, Fig. 1; ORTMANN, 1892, p. 295; RATHBUN, 1902, p. 37; BALSS, 1913, p. 44. TERAO, 1913, p. 362.

LOC. Station 108, near Inuboe-zaki, 35 m. deep. March 2, 1927. 8 males and 7 females.

Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 18 males and 12 females.

Station 389, near Lake Hamana, 76–91 m. deep. December 13, 1927. 1 male.

DISTRIBUTION: China Sea; Hongkong; Japan: Tokyo Bay, Bôsyû, Sagami Bay, Inland Sea, Nagasaki, Niigata and above locali-

ties. Depth: to 97 m.

Genus **PAGURUS** FABRICIUS.

120. Pagurus arrosor (HERBST).

Pagurus arrosor, BALSS, 1913, p. 46 (other literature and synonym); PARISI, 1918, p. 112.

LOC. Station 105, coast of Bôsyû, 130 m. deep. February 27, 1927. 1 female.

Station 112, south of Inuboe-zaki, 37 m. deep. March 2, 1927. 1 female.

Station 177, north of Kinkazan, 119 m. deep. July 29, 1923. 1 male.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 female.

Station 267, Suruga Bay, 64 m. deep. July 2, 1928. 1 male.

Station 365, south-east of Mie-ken, 93 m. deep. August 10, 1928. 1 male.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 male.

Station 388, south-east of Omae-zaki, 136–189 m. deep. December 12, 1927. 4 females.

Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 1 male.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 female.

Station 465, north of Gotô Isls., west of Hirato, 106 m. deep. July 24, 1929. 2 males.

Station no. missing. Tusima Strait, July 24, 1929. 3 males and 2 females, 1 bears eggs.

Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 male.

Station 493, north of Iwami, Simane-ken, 124 m. deep. August 12, 1929. 1 male.

Station 572, north of Noto, 132 m. deep. July 27, 1930. 1 male.

Northern Japan Sea. August 1930. 4 males and 2 females.

DISTRIBUTION: West Indies; Brazil; Mediterranean; Cadiz; Ma-

deira; Senegambia; West of Africa; St. Helena; Red Sea; Australia; Philippine Islands; Japan: Tokyo Bay, Sagami Bay, Sizuoka, Nagasaki, Niigata and above localities.

121. *Pagurus impressus* DE HAAN.

DE HAAN, 1849, p. 207, Pl. 49, Fig. 3; ALCOCK, 1905, p. 169; BALSS, 1913, p. 46, Figs. 30, 31; TERAO, 1913, p. 378.

LOC. Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 2 males and 1 egg-bearing female.
Station 420, south of Kosiki Isls., 132 m. deep. July 15, 1929. 1 male.
Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 1 male.

DISTRIBUTION: Ceylon; Japan: Sagami Bay, Suruga Bay, Wakanoura, Nagasaki and above localities.

Genus ANICULUS DANA.

122. *Aniculus aniculus* FABRICIUS.

Pagurus aniculus, MILNE-EDWARDS, 1836, p. 279; DE HAAN, 1849, p. 209.
Aniculus typicus, DANA, 1852, p. 461, Pl. 29, Fig. 1; ORTMANN, 1892, p. 289.
Aniculus aniculus, ALCOCK, 1905, p. 94; BALSS, 1913, p. 49.

LOC. Station 239, south of Misaki, 307 m. deep. November 6, 1927. 1 female.

DISTRIBUTION: Mozambique; Islands of Indian Ocean; Malayan Archipelago; New Zealand; Tuamotu Islands; Japan: Tokyo Bay Sagami Bay.

Subfamily Eupagurinae ORTMANN.

Genus PARAPAGURUS SMITH.

123. *Parapagurus pilosimanus* SMITH.

ALCOCK, 1905 p. 99; HANSEN, 1908, p. 29; BALSS, 1912, p. 96, Pl. 11, Figs. 1-6; 1913, p. 50.

LOC. Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 male.

Station 344, south of Muroto-zaki, 543 m. deep. July 29, 1928. 3 males.

DISTRIBUTION: Atlantic; Indian Ocean; Pacific: Port Otway; Valparaiso; Gulf of California; Papua; Philippine Islands; Japan: Okinose Bank and above locality.

Genus **EUPAGURUS** BRANDT.

124. ***Eupagurus anomalus*** BALSS.

BALSS. 1913, p. 53, Fig. 32.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 1 male and 2 females.

Station 98, north of Kinkazan, 106 m. deep. November 7, 1926. 1 male.

Station 126, between Kinkazan and Siwoya-zaki, 146 m. deep. March 7, 1927. 2 males.

Station 148, south of Kinkazan, 270 m. deep. August 3, 1925. 1 male.

Station 600, north of Sado Isl., 168 m. deep. August 9, 1930. 4 males and 1 egg-bearing female.

Station 628, south-west of Oga, 148 m. deep. August 17, 1930. 1 egg-bearing female.

Station 649, Tugaru Strait, 241 m. deep. August 23, 1930. 1 female.

Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 2 males.

Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 2 males.

Station 653, Tugaru Strait, 108 m. deep. August 24, 1930. 1 female.

Station 658, Tugaru Strait, 113 m. deep. August 30, 1930. 1 egg-bearing female.

DISTRIBUTION: Nagasaki and above localities. The present species seems to have northern distribution.

125. ***Eupagurus barbatus*** ORTMANN.

ORTMANN, 1892, p. 311; BALSS, 1913, p. 55.

LOC. Station 128, south of Kinkazan, 48 m. deep. March 10,

1927. 1 male.

North-east of Honsyû, February 1927. 1 young female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay and above localities.

126. *Eupagurus constans* STIMPSON.

STIMPSON, 1858, p. 248; 1907, p. 218, Pl. 24, Fig. 3; HENDERSON, 1888, p. 67, Pl. 6, Fig. 8; ORTMANN, 1892, p. 320; DOFLEIN, 1902, p. 647; ALCOCK, 1905, p. 177; BALSS, 1913, p. 55; TERAO, 1913, p. 366.

LOC. Station 132, between Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 2 males.

Station 273, south of Lake Hamana, 132 m. deep. July 2, 1928. 1 male.

Station 390, near Lake Hamana, 24–38 m. deep. December 13, 1927. 1 male and 4 egg-bearing females.

Station 620, south of Oga, 139 m. deep. August 15, 1930. 1 male.

Station 653, Tugaru Strait, 108 m. deep. August 24, 1930. 1 male.

DISTRIBUTION: Japan: Hakodate, Tokyo Bay, Sagami Bay, Nagasaki and above localities.

127. *Eupagurus dubius* ORTMANN.

ORTMANN, 1892, p. 307, Pl. 12, Fig. 14; DOFLEIN, 1902, p. 646; BALSS, 1913, p. 55.

LOC. Station 370, south of Atumi, east of Toba, Mie-ken, 91 m. deep. August 10, 1928. 1 male.

Station 461, west of Tusima Isl., 120 m. deep. July 24, 1929. 1 female.

The specimen from Station 370 is missing all legs.

DISTRIBUTION: Tokyo Bay, Sagami Bay and above localities.

128. *Eupagurus cavimanus* MIERS.

MIERS, 1879, p. 21 and 48, Pl. 3, Fig. 1; BALSS, 1913, p 58, Fig. 34.
Eupagurus munitus, BENEDICT, 1892, p. 19.
Pagurus munitus, RATHBUN, 1904, p. 161, Pl. 5, Fig. 2.
Eupagurus gotoi, TERAO, 1913, p. 366.

LOC. Station 21, east of Siwoya-zaki, 209 m. deep. June 27,

1926. 1 male.

Station 26, north-east of Siwoya-zaki, 232 m. deep. July 2, 1926. 1 female and 1 young specimen.

Station 33, south-east of Kinkazan, 331 m. deep. July 3, 1926. 2 males.

Station 58, north-east of Todo-saki, 177 m. deep. July 18, 1926. 3 males and 1 female.

Station 70, south-east of Siriya-zaki, 185 m. deep. July 26, 1926. 2 males and 1 female.

Station 523, off Tottori-ken, 181 m. deep. August 23, 1929. 1 female.

Station 602, north of Sado Isl., 205 m. deep. August 9, 1930. 1 young specimen.

Station 656, Tugaru Strait, 170 m. deep. August 30, 1930. 2 males.

DISTRIBUTION: Alaska; Bering Sea; Japan: above localities. I have examined some specimens from Ibaragi-ken.

129. Eupagurus ochotensis BRANDT.

Pagurus (Eupagurus) bernhardus var. C, spinimana; or sp. *ochotensis*, BRANDT, 1851, p. 108.
Pagurus ochotensis, BENEDICT, 1901, p. 463; RATHBUN, 1904, p. 157; SCHMITT, 1921, p. 130.
Eupagurus ochotensis, STIMPSON, 1907, p. 218; BALSS, 1913, p. 60.
Bernhardus armatus, DANA, 1852, p. 442, Pl. 27, Fig. 2.
Eupagurus ortmanni, BALSS, 1911, p. 7.

LOC. Station 94, south of Todo-saki, 130 m. deep. November 6, 1926. 5 males and 7 females.

Station 102, east of Sendai, 37 m. deep. November 10, 1926. 1 male.

Station 112, south of Inuboe-zaki, 37 m. deep. March 2, 1927. 1 female.

Station 128, south of Kinkazan, 48 m. deep. March 7, 1927. 8 males and 3 females, 1 bears eggs.

Station 165, between Kinkazan and Siwoya-zaki, 106 m. deep. November 21, 1925. 2 egg-bearing females.

Station 177, north of Kinkazan, 119 m. deep. July 29, 1923. 1 male.

Station 604, near Sado Isl., 444 m. deep. August 10, 1930. 1 male.

Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 1 male and 2 young specimens.

DISTRIBUTION: Vancouver Island to Sandiego, California; Ochotsk Sea; Aniwa Bay; Vladivostock; Japan: Hakodate, Nagasaki and above localities. Depth: 11–444 m.

130. Eupagurus pectinatus STIMPSON.

STIMPSON, 1858, p. 249; 1907, p. 220; BALSS, 1913, p. 60, Fig. 35 and Pl. 1, Fig. 8.

LOC. Station 459, west of Tusima Isl., 115 m. deep. July 23, 1929. 2 males and 1 female.

Station 474, north-west of Tusima Isl., 219 m. deep. July 28, 1929. 1 male and 4 females.

Station 580, Toyama Bay, 135 m. deep. July 29, 1930. 1 male.

Station 605, north of Sado Isl., 139 m. deep. August 10, 1930. 1 female.

Station 618, off the mouth of the River Mogami, 135 m. deep. August 14, 1930. 1 female.

Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 1 male and 1 female.

DISTRIBUTION: Castri Bay; Japan: Hakodate and above localities. Depth: 91–219 m.

131. Eupagurus hirsutiusculus (DANA).

Bernhardus hirsutiusculus, DANA, 1848, p. 443, Pl. 27, Fig. 3.
Eupagurus hirsutiusculus, STIMPSON, 1907, p. 223; BALSS, 1913, p. 62, Pl. 1, Fig. 9.

LOC. Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 3 males and 2 egg-bearing females.

DISTRIBUTION: From south California to Aleutian Islands and Bering Sea; east coast of Asia; Japan: Hakodate and above locality.

132. Eupagurus trigonocheirus STIMPSON.

STIMPSON, 1907, p. 221, Pl. 26, Fig. 2; BALSS, 1913, p. 63 (other literature and synonyms); TERAO, 1913, p. 373.

LOC. Station 18, between Siwoya-zaki and Inuboe-zaki, 583 m. deep. June 26, 1926. 1 male.
Station 60, north-east of Todo-saki, 477 m. deep. July 19, 1926. 1 female.
Station 73, south of Siwoya-zaki, 390 m. deep. July 27, 1926. 1 male.
Station 128, between Kinkazan and Siwoya-zaki, 48 m. deep. March 7, 1927. 1 male.
Station 429, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1927. 2 young specimens.
Station 487, far east of Huzan, Corea, 194 m. deep. August 11, 1929. 1 female.
Station 551, north of Mikuni, Hukui-ken, 274 m. deep. July 20, 1930. 2 egg-bearing females.
Station 570, north of Noto, 260 m. deep. July 27, 1930. 1 egg-bearing female.
Station 577, north-east of Noto, 311 m. deep. July 28, 1930. 1 female.
Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 1 female.

DISTRIBUTION: Arctic coast of Alaska and Siberia; Bering Sea; California; Kamtschatca; Japan: Ozika, Niigata and above localities.

133. Eupagurus conformis (DE HAAN).

Pagurus conformis, DE HAAN, 1849, p. 206; ORTMANN, 1892, p. 305; DOFLEIN, 1902, p. 647.

LOC. Station 140–141, east of Kinkazan, 344–680 m. deep. November 24, 1925. 1 male.
Station 271, west of Suno-saki, 82 m. deep. November 18, 1927. 1 female.
Station 295, north of Tanegasima Isl., 154 m. deep. July 11, 1928. 1 egg-bearing female.
Station 317, east of Miyazaki-ken, 97 m. deep. July 16, 1928. 1 male.
Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 1 egg-bearing female.
Station 447, near Gotô, Isls. 90 m. deep. July 20, 1929. 1

male and 1 female.
Station 451, west of Gotô Isls., 187 m. deep. July 22, 1929. 1 male.
Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 1 male and 1 egg-bearing female.
Station 484, north of Nagato, Yamaguti-ken, 93 m. deep. August 9, 1929. 2 males.

DISTRIBUTION: Japan: Sagami Bay, Kagosima and above localities.

134. *Eupagurus obtusifrons* ORTMANN.

ORTMANN. 1892, p. 313, Pl. 12, Fig. 18.

LOC. Station 132, between Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 5 males and 2 egg-bearing females.
Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 female.
Station 325, west of Asizuri-zaki, 210 m. deep. July 21, 1928. 1 male and 1 female.
Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 1 male and 1 female.
Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 male.
Station 655, Tugaru Strait, 112 m. deep. August 30, 1930. 3 males.

DISTRIBUTION: Japan: Sagami Bay and above localities. Depth: 48–393 m.

135. *Eupagurus japonicus* STIMPSON.

STIMPSON, 1858, p. 250; 1907, p. 226, Pl. 25, Fig. 2; ORTMANN, 1892, p. 309, Pl. 12, Fig. 16; BALSS, 1913, p. 56.

LOC. Station 239, south-west of Misaki, 307 m. deep. November 6, 1927. 2 males.
Station 466, west of Iki Isl., 110 m. deep. July 25, 1929. 1 egg-bearing female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay and Tusima Strait.

136. *Eupagurus similis* Ortmann.

Ortmann, 1892, p 310.

Loc. Station 79, near Siwoya-zaki, 102 m. deep. November 1, 1926. 1 male.

Station 107, between Siwoya-zaki and Inuboe-zaki, 115 m. deep. February 28, 1927. 1 male.

Station 293, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 1 male.

Station 320, Bungo Strait, 283 m. deep. July 16, 1928. 1 male.

Station 377, south of Omae-zaki, deep. August 14, 1928. 2 males and 2 egg-bearing females.

Distribution: Japan: Kagosima and above localities. Depth: 82–283 m.

137. *Eupagurus ophthalmicus* Ortmann.

Ortmann, 1892, p. 314, Pl. 12, Fig. 19.

Loc. Station 285, east of Omae-zaki, 71 m. deep. July 4, 1928. 1 male.

Station 318, Bungo Strait, 324 m. deep. July 16, 1928. 2 females.

Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 1 male.

Station 331, south of Asizuri-zaki, 344 m. deep. July 22, 1928. 1 male.

Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 male and 3 females.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

Station 637, north of Oga, 145 m. deep. August 18, 1930. 1 female.

Distribution: Japan: Sagami Bay and above localities.

138. *Eupagurus triserratus* Ortmann.

Ortmann, 1892, p. 308, Pl. 12, Fig. 15.

Loc. Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1

female.

Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 male and 1 female.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 male.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 2 males.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 male.

Station 524, off Tottori-ken, 88 m. deep. August 23, 1929. 1 male.

DISTRIBUTION: Japan: Sagami Bay and above localities. Depth: 51–160 m.

139. *Eupagurus lanuginosus* (DE HAAN).

Pagurus lanuginosus, DE HAAN, 1849, p. 207, Pl. 49, Fig. 5.

Eupagurus lanuginosus, ORTMANN, 1892, p. 312; BALSS, 1913, p. 56, Fig. 33.

LOC. Station 249, Sagami Bay, 229 m. deep. November 9, 1927. 1 young male.

Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 4 males and 1 female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Nagasaki and Hokkaidô. Depth: 110–229 m.

140. *Eupagurus nipponensis* n. sp.

(Text-fig. 32.)

LOC. Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 2 males and 2 females.

Station 238, south of Misaki, 106 m. deep. November 6, 1927. 1 male.

Station 267, Suruga Bay, 64 m. deep. November 18, 1927. 1 male and 1 egg-bearing female.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 2 males.

Station 278, south of Omae-zaki, 79 m. deep. July 2, 1928. 1 male and 1 egg-bearing female.

Station 288, south of Lake Hamana, 77 m. deep. July 2, 1928. 1 egg-bearing female.

Station 298, east of Sata-misaki, Kagosima-ken, 117 m. deep. July 11, 1928. 2 females, 1 bears eggs.

Station 360, south of Owase, Mie-ken, 123 m. deep. August 9, 1928. 1 male.

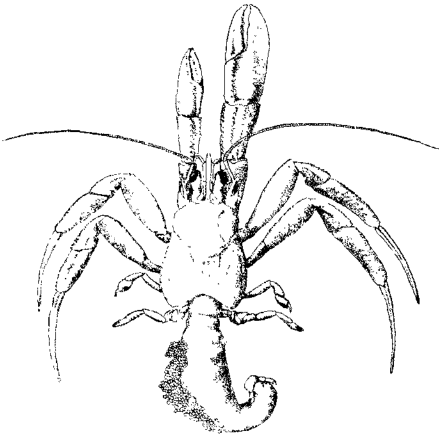
Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 3 females.

Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 male.

Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 5 males and 3 females.

Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 1 male and 1 female.

Body almost naked. Anterior half of carapace nearly as wide as long or somewhat wider than long; median projection of front as well as lateral projection sharply pointed, the former as long as or



Text-fig. 32. *Eupagurus nipponensis* n. sp. (×2)

somewhat longer than the latter. Eye-stalk stout, cornea dilated; ophthalmic scale distally pointed. Peduncle of first antenna nearly as long as that of second, exceeds the eye; antennal scale as long as or somewhat shorter than eye. Larger right cheliped with carpus dorsally granular, and a series of pointed teeth is on the inner margin. Palm of the chela a little shorter than carpus, but longer than finger; surface nearly smooth, some small granules noticeable under lens, but a series of somewhat conspicuous granules is along the outer margin. Left cheliped slender and shorter; carpus with two series of teeth on dorsal surface, nearly three-fourths as long as chela; palm almost as long as finger. Succeeding two pairs of legs similarly shaped; merus compressed, carpus with upper margin serrated and dactylus much longer than propodus.

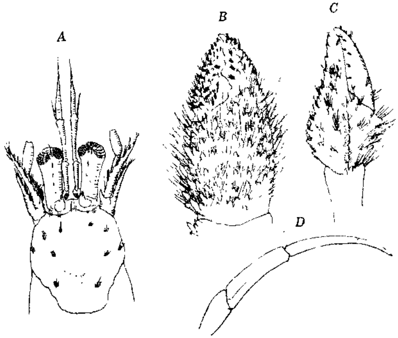
Dimension of an egg-bearing female from Station 298:

Length of carapace in the middle line	8.9 mm.
Width of carapace at the broadest point	7.8

141. Eupagurus gracilipes n. sp.

(Text-fig. 33.)

LOC. Station 353, near Tanabe, Wakayama-ken, 192 m. deep.



Text-fig. 33. *Eupagurus gracilipes* n. sp. *A*, Ophthalmic and antennal region of the animal, dorsal aspect (×2). *B*, Right chela (×3). *C*, Left chela (×3). *D*, Terminal half of 2nd leg (×1).

August 4, 1928. 3 males and 3 females, 1 bears eggs.

Near Eupagurus pectinatus STIMPSON, *but it differs from this in the following points:*

Ophthalmopods shorter. The peduncles of the first and the second antennae distinctly exceed the ophthalmic cornea, and the hairy acicle of the second antenna reaches the distal end of the eye. Legs slender.

142. Eupagurus brevimanus n. sp.

(Text-fig. 34.)

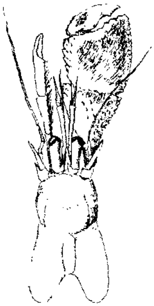
LOC. Station 208, near Siwo-misaki, 219 m. deep. July 13, 1927. 1 male.

Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 4 males.

Station 232, south-east of Muroto-zaki, 269 m. deep. July 30, 1927. 1 female and 2 broken right chelipeds.

Station 325, west of Asizuri-zaki, 210 m. deep. July 21, 1928. 2 egg-bearing females.

It is easily distinguishable from allied species in the feature of its vastly broad right cheliped; it is coarsely granular surfaced, the carpus and the chela are very broad, while the merus is rather narrow. The carpus distally increasing in width to the distal end, is almost as wide as long. In the chela, the palm is much wider than the length, the immovable finger is short and the movable finger, which is a little longer than the palm, is obliquely plicated. On the upper surfaces of the finger and the palm as well as near the distal margin of the carpus there are areas provided with woolly hairs. The left smaller cheliped is much slender, nearly smoothly surfaced; carpus and palm are provided with hairs along the inner margin.



Text-fig. 34. *Eupagurus brevimanus* n. sp.

The anterior half of the carapace is nearly as wide as long. The frontal margin is rounded in the middle; the lateral projections do not reach the level of the medial

front. The eye-stalk is moderately long and the basal scale is distally pointed. The peduncle of the first antenna is long nearly as long as twice the eye-stalk. In the second antenna, the acicula scarcely reaches to the distal end of the eye, and somewhat longer than the peduncle.

Genus SPIROPAGURUS STIMPSON.

143. *Spiropagurus spiriger* (DE HAAN).

Pagurus spiriger, DE HAAN, 1849, p. 206, Pl. 49, Fig. 2.
Spiropagurus spiriger, STIMPSON, 1858, p. 248; 1907, p. 214; HENDERSON, 1888, p. 72; ORTMANN, 1892, p. 292; RATHBUN, 1901, p. 37; BALSS, 1913, p. 65; TERAO, 1913, p. 386.

LOC. ? Northern Japan Sea, August 1930. 2 males.

DISTRIBUTION: East Indian Archipelago; Bay of Bengal; Maledive Islands; Zanzibar; Admirality Islands; Torres Strait; China Sea; Japan: Tokyo Bay, Wakayama, Kôti, Nagasaki. Above locality is doubtful as the level is missing. I have examined a specimen from Sizuoka-ken.

Genus CATAPAGURUS A. MILNE-EDWARDS.

144. *Catapagurus doederleini* DOFLEIN.

DOFLEIN, 1902, p. 624, Pl. 6, Figs. 4, 5, Text-fig. C; BALSS, 1913, p. 68, Fig. 41.

LOC. Station 107, near middle between Siwoya-zaki and Inuboe-zaki, 115 m. deep. February 28, 1927. 1 male.

DISTRIBUTION: Sagami Bay and above locality.

145. *Catapagurus japonicus* n. sp.

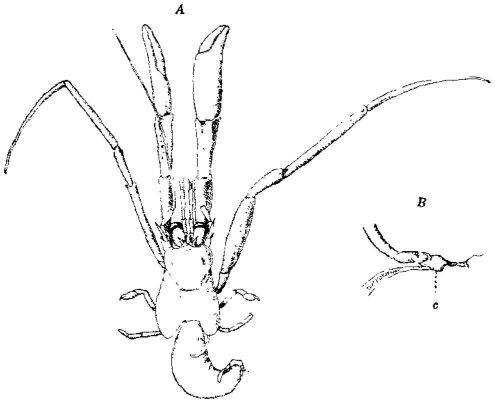
(Text-fig. 35.)

LOC. Station 179, south of Simoda, 189 m. deep. June 28, 1927. 1 female.
Station 194, near Maisaka, Sizuoka-ken, 192 m. deep. July 4, 1927. 1 female.
Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 egg-bearing female.
Station 301, east of Ariake Bay, Kagosima-ken, 181 m. deep. July 12, 1928. 1 male.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 2 males and 2 females.

Station 428, near middle between Nagasaki and Kcsiki Isls., 119 m. deep. July 16, 1929. 6 males and 3 females.

Anterior half of carapace nearly as long as wide, and rounded at antero-lateral margin. Median frontal projection pointed, a little exceeds lateral projection; dorsal surface uneven near frontal and lateral margin. Eye-stalk rather short and stout, a little dilated at cornea; ophthalmic scale slender and terminally pointed. Inner antenna long and exceeds the eye by the length of a part of second peduncular joint, terminal joint very long, nearly as long as proximal two joints. Outer antenna almost reaches the extremity of the eye with second peduncular joint; scale a little longer than the second peduncular joint. Chelipeds nearly naked and subequal in length; the right stouter than the left. Carpus dorsally with two blunt ridges; chela smooth. The finger in the right hand is a little longer than a half of the palm, while in the left it is somewhat longer than one and a half-times of the palm. Succeeding two pairs



Text-fig. 35. *Catapagurus japonicus* n. sp.
A, Entire animal (×3). *B*, Proximal half of last leg (right side). *c*, Coxa of the leg.

of legs long and slender; anterior shorter than posterior, but dactyli longer than propoda in both. Vas deference in male producing long.

Genus **CERATOPAGURUS** n. gen.

Near *Nematopagurus*. A paired appendage on female only. Vas deference not produced in male.

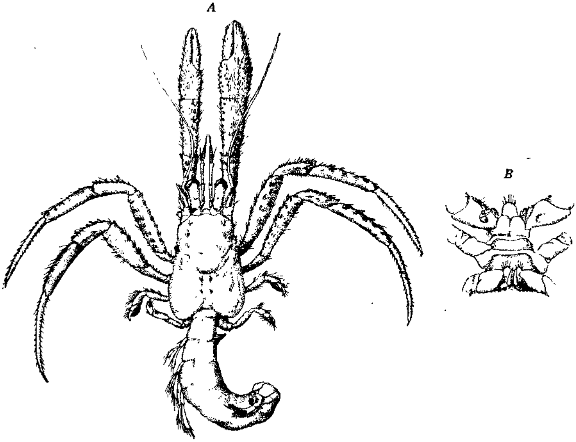
146. *Ceratopagurus pilosimanus* n. sp.

(Text-fig. 36.)

LOC. Station 296, east of Tanegasima Isl., 219 m. deep. July 11, 1928. 1 female.

Station 349, Kii Strait, 152 m. deep. August 2, 1928. 1 female.

Station 393, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 2 males and 2 females.



Text-fig. 36. *Ceratopagurus pilosimanus* n. sp.
A, Entire animal (×2). *B*, Bases of posterior 3 legs, ventral aspect.

Anterior half of carapace a little longer than broad; dorsally smooth in the middle; front rounded in the middle. Eye-stalk moderate in length and in width, a little longer than one half the length of the anterior half of the carapace. Cornea a little dilated; ophthalmic scale small and terminally pointed. The peduncle of the first antenna exceeds the end of cornea with about three-fourths the length of terminal joint. In the second antenna, the asicule curving outwards, is setose and nearly reaches the end of the cornea; the peduncle is distinctly longer than the eye.

Chelipeds pilose, especially so on the dorsal surfaces of the wrist and the palm; the right is a little larger than the left, but both are almost alike in feature; not only the carpus and the palm are pilose, but spinules are arranged in some numbers of longitudinal series, and the palm is a little longer than broad. The palm, however, is nearly as long as the finger in the right hand, but in the left it is shorter. Second and third legs longer than chelipeds, sparcely setose and unarmed except a series of spinules on the anterior margin of the carpus; dactyli terminate in a sharp claw and have some spinules on the posterior margins; propodus of third leg about as long as merus.

The paired appendage of the first abdominal somite of the female is slender and two-jointed.

Family **Lithodidae** BOUVIER.

Genus **LITHODES** LATREILLE.

147. ***Lithodes aequispinus*** BENEDICT.

BENEDICT, 1848, p. 481; BOUVIER, 1899, p. 173.

LOC. Station 22, east of Siwoya-zaki, 539 m. deep. June 22, 1926. 1 young male.

Specimen very small. Carapace 16.2 mm. long, measuring from the bifurcation of the rostral horn to the middle of the posterior margin, and 13.0 mm. broad (distance between the tips of lateral spines). The spines on the body surface are as a whole very conspicuous, but not sharply pointed.

DISTRIBUTION: Bering Sea and above locality.

Genus **ACANTHOLITHUS** STIMPSON.

148. Acantholithus hystrix (DE HAAN).

Lithodes hystrix, DE HAAN, 1849, p. 218, Pl. 48, Fig. 1.
Acantholithus hystrix, STIMPSON, 1858, p. 231; DOFLEIN, 1902, p. 648; BALSS, 1913, p. 75.
Paralomis hystrix, ORTMANN, 1892, p. 321, Pl. 12, Fig. 27.

LOC. Station 387, south of Maisaka, Sizuoka-ken, 189–252 m. deep. December 11, 1927. 1 male.

DISTRIBUTION: Japan: Sagami Bay and above locality. Depth: to 350 m.

TRIBE DROMIACEA.

Family **Dynomenidae** ORTMANN.

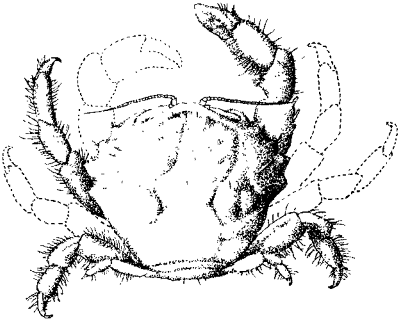
Genus **DYNOMENE** LATREILLE.

149. Dynomene hispida DESMAREST.

(Text-fig. 37.)

MILNE-EDWARDS, 1837, p. 180; 1849, Pl. 40, Fig. 2; A. MILNE-EDWARDS, 1879, p. 5, Pl. 12, Figs. 1–9, Pl. 13, Figs 10–15; DE HAAN, 1888, p. 408; ORTMANN, 1892, p. 543; ALCOCK, 1901, p. 74; RATHBUN, 1911, p. 195.

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. July



Text-fig. 37. *Dynomene hispida* DESMAREST (×2).

14, 1927. 1 female.
Station 229, south of Asizuri-zaki, 256 m. deep. July 27, 1927. 1 male.
Station 294, north of Tanegasima Isl., 102 m. deep. July 1928. 2 males and 1 egg-bearing female.

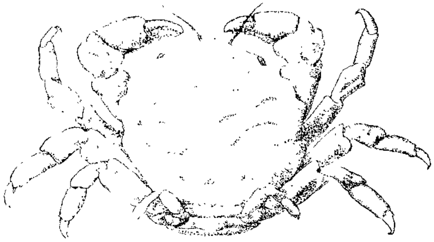
Marginal teeth of carapace somewhat obtuse.

DISTRIBUTION: Indian Ocean; New-Caledonia; Sandwich Islands; Amami Ôsima; from Japan proper it has not hitherto been reported.

150. Dynomene tanensis n. sp.

(Text-fig. 38.)

LOC. Station 296, east of Tanegasima Isl., 219 m. deep. July 11, 1928. 1 egg-bearing female.



Text-fig. 38. *Dynomene tanensis* n. sp. (×2).

Carapace and appendages except extremities of legs covered with short and dense hairs; and with a few long setae on the margins of legs. Carapace subcircular, regions marked by some transverse grooves; five antero-lateral teeth very shallow and obtuse. Front broad triangular, grooved in the medial line. Upper and lower margin of orbit smooth, outer angle rounded. Meri and carpi of legs irregularly tuberculated. Chelipeds subequal, stouter and longer than succeeding legs; fingers naked near the extremities, with deeply excavated extremities, inner edges dentate, gaping at the base when closed; last leg slender and shorter than one half of the preceding leg, the tip minutely chelate.

Family **Dromiidae** ALCOCK.

Genus **DROMIA** FABRICIUS.

151. Dromia pseudogibbosa PARISI.

PARISI, 1915, p. 5, Pl. 2, Figs. 1, 2; BALSS, 1922, p. 106.

LOC. Station 229, south of Asizuri-zaki, 256 m. deep. July 27, 1927. 1 male.
Station 271, west of Suno-saki, 82 m. deep. November 18, 1927. 1 male.
Station 272, west of Suno-saki, 612 m. deep. November 18, 1927. 1 male.
Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 male.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male and 2 females.
Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 1 female.
Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 1 female.
Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 1 male and 1 female.
Station 292, west of Tanegasima Isl., 126 m. deep. July 10, 1928. 1 male.
Station 333, south of Asizuri-zaki, 179 m. deep. July 22, 1928. 1 egg-bearing female.
Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 egg-bearing female.
Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 1 male and 2 females.
Station 466, west of Iki Isl., 110 m. deep. July 25, 1929. 1 female.
Station 524, off Tottori-ken, 88 m. deep. August 23, 1929. 1 male.
Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 male and 1 female.
Station 568, north of Noto, 90 m. deep. July 27, 1930. 3 males and 7 females.
Station 646, west of Ryûhi-zaki, Aomori-ken, 123 m. deep.

August 22, 1930. 3 males.
Station 654, Tugaru Strait, 44 m. deep. August 30, 1930. 1 female.

DISTRIBUTION: Japan: Sagami Bay and above localities.

Genus CRYPTODROMIA STIMPSON.

152. *Cryptodromia ihlei* BALSS.

BALSS, 1922, p. 107, Fig. 2.

LOC. Station 317, coast of Miyazaki-ken, 97 m. deep. July 16, 1928. 1 male.
Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 female.
Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 male.
Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1929. 1 female.

DISTRIBUTION: Tokyo Bay, Sagami Bay and above localities. Depth: 97–150 m.

153. *Cryptodromia incisa* HENDERSON.

HENDERSON, 1888, p. 10, Pl. 1, Fig. 4; ALCOCK, 1901, p. 77.

LOC. Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 1 female.

DISTRIBUTION: Twofold Bay, Australia; from Japanese waters it has not been recorded.

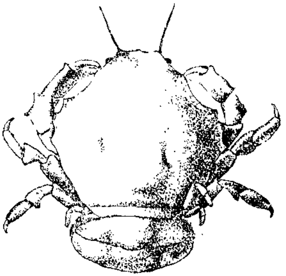
154. *Cryptodromia nipponensis* n. sp.

(Text-fig. 39.)

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 1 male.
Station 232, south-east of Muroto-zaki, 269 m. deep. July 30, 1927. 1 broken carapace.
Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 1 female.

Body semispherical; surface smooth in female, but slightly granular in male. Front truncated, projects horizontally and a little con-

cave in dorsal aspect. External orbital corner very obtuse; three or four notches are behind this. Regions on carapace not sharply defined, but gastric and cardiac regions slightly convex. On each side of the cardiac region there is a curved shallow groove. Cheliped in male somewhat stronger than that of female; merus produces to a point at the distal inner corner, carpus with two tubercles on the outer margin; chela compressed, palm with a basal tubercle.



Text-fig. 39. *Cryptodromia nipponensis* n. sp. (×3)

Family **Homolidae** HENDERSON.

Genus **HOMOLA** LEACH.

155. Homola barbata orientalis HENDERSON.

DOFLEIN, 1904, p. 14 (previous literature and synonyms); PARISI, 1915, p. 109; BALSS, 1922, p. 111.

LOC. Station 270, Sagami Bay, 91 m. deep. November 18, 1927. 1 male and 1 female.
Station 271, west of Suno-saki, 82 m. deep. November 18, 1927. 2 females.
Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 egg-bearing female.
Station 388, south of Hamana Lake, 136–189 m. deep. December 12, 1927. 1 male.

DISTRIBUTION: Andaman Sea; Sumatra; Little Ki Island; Philippine Islands; Japan: Sagami Bay, Tanabe. Depth: 40–400 m.

Subgenus Parahomola WOOD-MASON.

156. Homola (Parahomola) joponica PARISI.

PARISI, 1915, p. 109, Pl. 3; BALSS, 1922, p. 111.
Homola cuvieri, BALSS, 1921, p. 178.

LOC. Station 326, west of Tanegasima Isl., 392 m. deep. Jul 21, 1928. 1 male and 3 females, 1 bears eggs.

In two female specimens, the lateral rostral horns are simpl and in a male and a female, the merus and the carpus of the la leg are provided with some spinules above.

DISTRIBUTION: Mediterranean and north Atlantic; Japan: S gami Bay and above locality.

Genus **LATREILLIA** ROUX.

157. Latreillia phalangium DE HAAN.

DE HAAN, 1839, p. 108, Pl. 30, Fig. 2; ORTMANN, 1892, p. 542, Pl. 2 Fig. 2; DOFLEIN, 1902, p. 645; PARISI, 1915, p. 116; BALSS, 192 p. 111.

LOC. Station 165, north-east of Siwoya-zaki, off Ukedo, 106 n deep. November 27, 1926. 1 female.

Station 212, west of Tanabe, Wakayama-ken, 181 m. dee July 14, 1927. 1 female.

Station 222, west of Muroto-zaki, 210 m. deep. July 2 1927. 1 male.

Station 238, entrance of Tokyo Bay, 106 m. deep. N vember 6, 1927. 1 male.

Station 239, south of Misaki, 307 m. deep. November 1927. 1 egg-bearing female.

Station 271, west of Suno-saki, 82 m. deep. November 1 1927. 1 male and 1 egg-bearing female.

Station 274, Suruga Bay, 51 m. deep. July 2, 1928. female.

Station 276, near Omae-zaki, 77 m. deep. July 2, 1928. females, 1 bears eggs.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. egg-bearing female.

Station 282, Suruga Bay, 110 m. deep. July 4, 1928. male.

Station 284, east of Omae-zaki, 71 m. deep. July 4, 192 1 male.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. male.

Station 287, near Omae-zaki, 73 m. deep. July 4, 1928. 1 female.

Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 1 male and 1 female.

Station 295, north of Tanegasima Isl., 154 m. deep. July 11, 1928. 2 males and 2 egg-bearing females.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 2 males and 3 egg-bearing females.

Station 317, coast of Miyazaki-ken, 97 m. deep. July 16, 1928. 1 female.

Station 319, Bungo Strait, 210 m. deep. July 16, 1928. 1 male and 1 egg-bearing female.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 female.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 2 males.

Station 370, south of Atumi, Aiti-ken, 91 m. deep. August 10, 1928. 1 egg-bearing female.

Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 1 male.

Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 1 female.

Station 418, south of Satuma, Kagosima-ken, 133 m. deep. July 14, 1929. 1 female.

Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1929. 2 egg-bearing females.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 egg-bearing female.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 male and 1 egg-bearing female.

Station 466, west of Iki Isl., 110 m. deep. July 25, 1929. 1 female.

Station 471, west of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 female.

Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 egg-bearing female.

Station 540, near Kyôga-saki, 123 m. deep. August 25, 1929. 1 male.

Station 572, north of Noto, 132 m. deep. July 27, 1930.

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3 egg-bearing females.

Station 575, north of Noto, 123 m. deep. July 28, 1930. 1 egg-bearing female.

Station 606, north of Sado Isl., 117 m. deep. August 10, 1930. 3 females, 1 bears eggs.

Station 638, west of Tubaki-zaki, Aomori-ken, 73 m. deep. August 18, 1930. 1 male.

Station 646, west of Ryûhi-zaki, 123 m. deep. August 22, 1930, 3 females, 2 bear eggs.

Station 647, south-west of Ryûhi-zaki, 86 m. deep. August 23, 1930. 1 female.

Station 648, far west of Ryûhi-zaki, 247 m. deep. August 23, 1930. 1 male.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Suruga Bay and above localities. Depth: 51–307 m.

158. Latreillia valida DE HAAN.

DE HAAN, 1839, p. 107, Pl. 30, Fig. 1; ALCOCK, 1901, p. 80; DOFLEIN, 1902, p. 649; RATHBUN, 1902, p. 32; IHLE, 1913, p. 81; BALSS, 1922, p. 114.

Latreillia pennifera, ALCOCK, 1901, p. 71, Pl. 7, Fig. 27; RATHBUN, 1911, p. 196; IHLE, 1913, p. 82.

LOC. Station 232, south-east of Simoda, 269 m. deep. July 30, 1927. 1 male.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 female.

Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 female.

Station 407, between Kôti and Asizuri-zaki, 97 m. deep. December 7, 1928. 1 egg-bearing female.

Station 407, between Kôti and Asizuri-zaki, 100 m. deep. December 7, 1928. 2 males.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 female.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 female.

Station 575, north of Noto, 123 m. deep. July 29, 1930. 1 male.

Station 587, Toyama Bay, 97 m. deep. August 2, 1930. 1 egg-bearing female.
Station 594, north-west of Niigata, 72 m. deep. August 4, 1930. 1 egg-bearing female.
Station no. missing, Tusima Strait, off Gotô Isls., 60 fms. deep. 10 males and 6 egg-bearing females.

Occurence of egg-bearing females in August and December seems to be extraordinary.

DISTRIBUTION: Ki Islands; Mergui Archipelago; Bay of Bengal; Gulf of Martaban; western Indian Ocean; Philippine Islands; Japan: Sagami Bay and above localities.

Genus **LATREILLOPSIS** HENDERSON.

159. Latreillopsis bispinosa HENDERSON.

HENDERSON, 1888, p. 22, Pl. 2, Fig. 3; DOFLEIN, 1902, p. 650, Pl. 4, Figs. 3, 4; IHLE, 1913, p. 77; BALSS, 1922, p. 115.

LOC. Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 female.
Station 305, east of southern Miyazaki-ken, 137 m. deep. July 12, 1928. 1 male.
Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 male.

DISTRIBUTION: Andaman Sea; Philippine Islands; Japan: Sagami Bay and above localities. Depth: 97–210 m.

TRIBE OXYSTOMATA.

Family **Dorippidae** DANA.

Subfamily Tymolinae ALCOCK.

Genus **TYMOLUS** STIMPSON.

160. Tymolus uncifer (ORTMANN).

Cyclodorippe uncifera, ORTMANN, 1892, p. 560, Pl. 26, Fig. 6; DOFLEIN, 1902, p. 653; 1904, p. 34, Pl. 12, Figs. 4-7; PARISI, 1914, p. 297, Pl. 13, Fig. 2; IHLE, 1916, p. 134.
Cymonomops glaucomma, ALCOCK, 1896, p. 286.
Tymolus uncifer, BALSS, 1922, p. 116.

LOC. Station 41, between Todo-saki and Kinkazan, 177 m. deep.

July 9, 1926. 1 male.

Station 83, far south of Siriya-zaki, 55 m. deep. November 2, 1926. 1 male.

Station 95, between Todo-saki and Kinkazan, 141 m. deep. November 7, 1926. 13 males and 11 egg-bearing females.

Station 97, north of Kinkazan, 123 m. deep. November 7, 1926. 1 egg-bearing female.

Station 98, north of Kinkazan, 106 m. deep. November 7, 1926. 3 males and 1 female.

Station 114, east of Inuboe-zaki, 95 m. deep. March 3, 1927. 1 female.

Station 119, between Siwoya-zaki and Inuboe-zaki, 124 m. deep. March 4, 1927. 5 males and 2 females.

Station 120, south of Siwoya-zaki, 141 m. deep. March 4, 1927. 1 male and 1 female.

Station 121, south-east of Siwoya-zaki, 102 m. deep. March 4, 1927. 1 male and 2 females.

Station 127, south of Kinkazan, 146 m. deep. March 7, 1927. 1 male.

Station 130, north-east of Siwoya-zaki, 104 m. deep. March 12, 1927. 1 female.

Station 143, east of Siwoya-zaki, 132 m. deep. November 30, 1925. 1 male and 1 female.

Station 146, east of Siwoya-zaki, 201 m. deep. November 30, 1925. 4 males and 6 females, 1 bears eggs.

Station 227, north-east of Asizuri-zaki, 348 m. deep. July 22, 1927. 1 egg-bearing female.

Station 244, Sagami Bay, 135 m. deep. November 7, 1927. 1 male.

Station 247, Kii Strait, 128–159 m. deep. November 8, 1927. 5 males and 8 females, 7 bear eggs.

Station 248, Sagami Bay, 170 m. deep. November 8, 1927. 1 male and 1 female.

Station 253, Sagami Bay, 452 m. deep. November 9, 1927. 1 male and 4 egg-bearing females.

Station 423, south of Kosiki Isls., 243 m. deep. July 15, 1929. 2 egg-bearing females.

Station 575, north of Noto, 123 m. deep. July 28, 1930.

1 female.

The hook near the distal end of the merus is noticeable on the second leg, while in many cases there is no one on that of third leg.

Guessing from above materials, females from northern localities, bear eggs in winter and those from southern in summer.

DISTRIBUTION: East coast of Africa; Andaman Sea; Japan: Sagami Bay and above localities.

161. *Tymolus japonicus* STIMPSON.

STIMPSON, 1858, p. 168; 1907, p. 109, Pl. 19, Fig. 3; BALSS, 1922, p. 116.

Cyclodorippe dromioides, ORTMANN, 1892, p. 559, Pl. 26, Fig. 5; DOFLEIN, 1904, Pl. 12, Fig. 8; PARISI, 1914, p. 299.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 6 males and 4 females.

Station 46, between Todo-saki and Kinkazan, 165 m. deep. July 9, 1926. 1 male and 3 females, 2 bear eggs.

Station 53, east of Todo-saki, 190 m. deep. July 16, 1926. 1 male.

Station 64, north of Todo-saki, 150 m. deep. July 21, 1926. 1 egg-bearing female and 1 broken specimen.

Station 85, between Siriya-zaki and Todo-saki, 91 m. deep. November 2, 1926. 1 female.

Station 86, between Siriya-zaki and Todo-saki, 86 m. deep. November 2, 1926. 1 male and 2 egg-bearing females.

Station 88, north of Todo-saki, 135 m. deep. November 2, 1926. 1 female.

Station 90, near Todo-saki, 152 m. deep. November 3, 1926. 10 males and 6 females.

Station 91, near Todo-saki, 154 m. deep. November 6, 1926. 1 male.

Station 94, south of Todo-saki, 130 m. deep. November 6, 1926. 1 male and 1 egg-bearing female.

Station 105, coast of Bôsyû, 130 m. deep. February 27, 1927. 1 male.

Station 109, south-east of Inuboe-zaki, 123 m. deep. March

2, 1927. 1 egg-bearing female.

Station 126, south of Kinkazan, 146 m. deep. March 7, 1927. 2 males and 1 female.

Station 131, south of Siwoya-zaki, 99 m. deep. March 14, 1927. 1 male and 1 female.

Station 139–140, east of Kinkazan, 320–344 m. deep. November 24, 1925. 5 males and 6 females.

Station 194, near of Maisaka, Sizuoka-ken, 192 m. deep. July 4, 1927. 1 female.

Station 199, south of Toba, Mie-ken, 207 m. deep. July 11, 1927. 1 male.

Station 251, Sagami Bay, 165 m. deep. November 9, 1927. 1 egg-bearing female.

Station 266, Suruga Bay, 128 m. deep. November 18, 1927. 1 egg-bearing female.

Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 1 female.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 male.

Station 293, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 1 male.

Station 317, Bungo Strait, 97 m. deep. July 16, 1928. 3 males and 1 female.

Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 1 female.

Station 329, west of Asizuri-zaki, 296 m. deep. July 22, 1928. 1 egg-bearing female.

Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 2 males.

Station 367, south-east of Toba, Mie-ken, 291 m. deep. August 10, 1928. 2 females.

Station 370, south of Atumi, Aiti-ken, 91 m. deep. August 10, 1928. 2 females, 1 bears eggs.

Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 male.

Station 435, south of Gotô Isls., 324 m. deep. July 18, 1929. 1 egg-bearing female.

Station 459, west of Tusima Isl., 115 m. deep. July 23, 1929. 1 male and 1 female.

Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 2 egg-bearing females.
Station 485, east of Misima Isl., 93 m. deep. August 11, 1929. 2 egg-bearing females.
Station 546, Wakasa Bay, 101 m. deep. July 20, 1930. 1 female.
Station 572, north of Noto, 132 m. deep. July 27, 1930. 2 females, 1 bears eggs.
Station 580, Toyama Bay, 135 m. deep. July 29, 1930. 2 males.
Stntion 645, west of Lake Zyûsan-gata, Aomori-ken, 115 m. deep. August 22, 1930. 1 egg-bearing female.
Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 3 males and 4 females, 3 bear eggs.
Station 653, Tugaru Strait, 108 m. deep. August 24, 1930. 15 males and 9 egg-bearing females.
Station 654, Tugaru Strait, 44 m. deep. August 30, 1930. 1 female.

According to the above materials, in many cases egg-bearing specimens occur in summer, while the specimens collected in November from eastern sea of Honsyû are ovigerous.

DISTRIBUTION: Japan: Hakodate, Sagami Bay and above localities. Depth: 44–344 m.

Subfamily Dorippinae ALCOCK.

Genus **DORIPPE** FABRICIUS.

162. *Dorippe granulata* DE HAAN.

DE HAAN, 1841, p. 122, Pl. 31, Fig. 2; ORTMANN, 1892, p. 561; RATHBUN, 1902, p. 31; STIMPSON, 1907, p. 168; PARISI, 1914, p. 301; BALSS, 1922, p. 119.

LOC. Station 91, near Todo-saki, 154 m. deep. November 10, 1926. 6 males and 17 females.
Station 101, west of Kinkazan, 40 m. deep. November 10, 1926. 3 males.
Station 108, near Inuboe-zaki, 35 m. deep. March 2, 1927. 1 male.
Station 115, south-west of Inuboe-zaki, 18 m. deep. March

3, 1927. 1 male.

Station 125, between Siwoya-zaki and Kinkazan, 44 m. deep. March 6, 1927. 3 females.

Station 128, south of Kinkazan, 48 m. deep. March 10, 1927. 5 males and 6 females.

Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 1 male and 2 females.

Station 167, near Kinkazan, depth unrecorded. November 21, 1926. 1 female.

Station 168, near Kinkazan, depth unrecorded. November 21, 1926. 1 male.

Station 267, Suruga Bay, 64 m. deep. November 18, 1927. 1 male.

Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 male.

Station no. missing, Tusima Strait, off Gotô Isls., 60 fms. deep. July 24, 1928. 1 male.

Station 465, north of Gotô Isls., west of Hirato, 106 m. deep. July 24, 1929. 1 male.

Station 470, between Simonoseki and Iki Isl., 37 m. deep. July 25, 1929. 1 egg-bearing female.

Station 632, north of Oga, 71 m. deep. August 17, 1930. 1 male and 1 female.

Station 645, west of Lake Zyûsan-gata, Aomori-ken, 115 m. deep. August 22, 1930. 1 male.

DISTRIBUTION: Vladivostock; China Sea; Japan: Kyûsyû, Sikoku, Honsyû. Depth: to 154 m.

163. Dorippe japonica DE HAAN.

DE HAAN, 1841, p. 122, Pl. 31, Fig. 1; IVES, 1891, p. 216; PARISI, 1914, p. 302; BALSS, 1922, p. 119.

LOC. Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 female.

DISTRIBUTION: Japan: Hakodate, Kuzyûkuri (Hidati), Inland Sea, Sagami Bay and above locality.

Genus **ETHUSA** ROUX.

164. Ethusa sexdentata STIMPSON.

Dorippe sexdentata, STIMPSON, 1858, p. 163.
Ethusa andamanica, ALCOCK, 1894, p. 405; 1896, p. 284; Illustrations Investigator, Crustacea, Pl. 14, Fig. 8; DOFLEIN, 1904, p. 37, Pl. 13, Figs. 7, 8; PARISI, 1914, p. 302, Text-figs. 3, 4.
Ethusa sexdentata, STIMPSON, 1907, p. 168, Pl. 19, Fig. 4; BALSS, 1922, p. 120.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 2 males and 6 females, 5 bear eggs.
Station 113, south of Inuboe-zaki, 196 m. deep. March 2, 1927. 1 male.
Station 181, Suruga Bay, 187 m. deep. June 28, 1927. 1 female.
Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 male.
Station 214, Kii Strait, 166 m. deep. July 18, 1927. 1 male.
Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 male.
Station 255, north-east of Simoda, 263 m. deep. November 10, 1927. 2 females.
Station 268, south of Simoda, 549 m. deep. November 18, 1927. 1 male.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 female.
Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 1 male.
Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 egg-bearing female.
Station 299, east of Kagosima-ken, 115 m. deep. July 11, 1928. 1 male.
Station 303, east of Kagosima-ken, 364 m. deep. July 12, 1928. 1 male and 3 females, 2 bear eggs.
Station 318, Bungo Strait, 324 m. deep. July 16, 1928. 1 male.
Station 321, Bungo Strait, 457 m. deep. July 16, 1928. 1 male.
Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 2 males and 3 females.

Station 329, west of Asizuri-zaki, 296 m. deep. July 22, 1928. 1 male and 1 female.

Station 330, near Asizuri-zaki, 102 m. deep. July 22, 1928. 1 female.

Station 343, south of Muroto-zaki, 366 m. deep. July 28, 1928. 1 male.

Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1 female.

Station 353, near Tanabe, Wakayama-ken, 192 m. deep. August 4, 1928. 1 male.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 egg-bearing female.

Station 417, south of Satuma, Kagosima-ken, 192 m. deep. July 14, 1929. 1 male and 1 egg-bearing female.

Station 420, south of Is. Kosiki, 132 m. deep. July 16, 1929. 1 male.

Station 435, south of Gotô Isls., 324 m. deep. July 18, 1929. 2 females.

Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 1 male.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 female.

Station 446, near Gotô Isls., 117 m. deep. July 20, 1929. 1 egg-bearing female.

Station 447, near Gotô Isls., 90 m. deep. July 20, 1929. 1 male.

Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 1 female.

DISTRIBUTION: Andaman Sea; Sombrero Channel; Japan: Kagosima, Sagami Bay and above localities.

Family **Raninidae** DANA.

Genus **LYREIDUS** DE HAAN.

165. Lyreidus tridentatus DE HAAN.

DE HAAN, 1841, p. 140, Pl. 35, Fig. 6; HASWELL, 1882, p. 144; HENDERSON, 1888, p. 33; ORTMANN, 1893, p. 574; DOFLEIN, 1902, p. 654; 1904, p. 52; PARISI, 1614, p. 306; BALSS, 1922, p. 121.

Lyreidus elongatus, MIERS, 1879, p. 46.

LOC. Station 5, east of Bôsyû, 269 m. deep. June 17, 1926. 1 male.

Station 103, east of Bôsyû, 117 m. deep. February 26, 1927. 1 male.

Station 104, east of Bôsyû, 124 m. deep. February 27, 1927. 1 male.

Station 105, east of Bôsyû, 130 m. deep. February 27, 1927. 1 female.

Station 113, south of Inuboe-zaki, 196 m. deep. March 2, 1927. 1 male and 1 egg-bearing female.

Station 195, south of Lake Hamana, 172 m. deep. July 2, 1927. 1 female.

Station 199, south of Sima, Mie-ken, 207 m. deep. July 11, 1927. 2 males.

Station 201, north-east of Owase, Mie-ken, 183 m. deep. July 11, 1927. 1 female.

Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 female.

Station 226, north-east of Asizuri-zaki, 223 m. deep. July 23, 1927. 1 female.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 2 females.

Station 304, Bungo Strait, 241 m. deep. July 12, 1928. 1 male.

Station 341, south of Kôti, 126 m. deep. July 28, 1928. 1 female.

Station 365, south of Hamazima, Mie-ken, 93 m. deep. August 10, 1928. 1 male.

Station 406. south of Kôti, 97 m. deep. May 3, 1928. 2 males.

Station 434, south of Gotô Isls., 238 m. deep. July 18, 1929. 1 female.

Station 580, Toyama Bay, 135 m. deep. July 29, 1930. 1 male and 4 females.

DISTRIBUTION: Dar-es-Salaam; Australia; Fiji Islands; Kandavu; New Caledonia; Japan: Tokyo Bay, Sagami Bay and above localities. Station 580 is the northern limit. Depth in Japan: 93–269 m.

166. *Lyreidus polytus* PARISI.

PARISI, 1914, p. 311, Pl. 13, Fig. 5.

LOC. Station 422, west of Satuma, Kagosima-ken, 88 m. deep. July 15, 1929. 1 male.

DISTRIBUTION: It has hitherto been known from Sagami Bay only.

Genus NOTOPUS DE HAAN.

167. *Notopus dorsipes* (FABRICIUS).

DE HAAN, 1841, p. 139, Pl. 35, Fig. 5; ALCOCK, 1896, p. 290; IHLE, 1918, p. 294; BALSS, 1922, p. 122.

LOC. Station 292, west of Tanegasima Isl., 126 m. deep. 1 broken specimen.

DISTRIBUTION: Red Sea; Zanzibar; Mauritius; Andaman Sea; Malabar; Sulu and Banda Sea; Japan: Sagami Bay and above locality.

168. *Notopus ovalis* HENDERSON.

HENDERSON, 1888, p. 31, Pl. 2, Fig. 6.

LOC. Station 179, near Irô-zaki, 187 m. deep. June 28, 1927. 2 males.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 1 broken specimen.

Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1 male.

Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 female.

Notch on the lateral margin is somewhat shallower in the present specimens.

DISTRIBUTION: Ki Islands and above localities.

Genus RANINA LAMARCK.

169. *Ranina ranina* LINNAEUS.

Cancer ranina, LINNAEUS, 1758, p. 625.
Ranina dentata, DE HAAN, 1841, p. 139, Pls. 34, 35, Figs. 1-4; MILNE-EDWARDS, 1837, p. 194, Pl. 21, Figs. 1-4; HASWELL, 1882, p. 144.
Ranina serrata, ORTMANN, 1892, p. 575; DE MAN, 1902, p. 685; BORRADAILE, 1903, Pl. 22, Fig. 5.

Ranina scabra, STEBBING. 1903, p. 16; BOUVIER, 1915, p. 48; IHLE, 1918, p. 295.
Ranina ranina, PARISI, 1914, p. 312; BALSS, 1922, p. 122.

LOC. Station 401, east of Owase, Mie-ken, 303 m. deep. March 2, 1928. 1 male.

DISTRIBUTION: St. Thomé; Cape of Good Hope; Mauritius; Reunion; Indian Ocean; East Australia; Hawaii; Loochoo Islands; Japan: Kagosima, Owase, Sagami Bay.

Genus RANINOIDES MILNE-EDWARDS.

170. Raninoides personatus WHITE.

HENDERSON, 1888, p. 27, Pl. 2, Fig. 5.

LOC. Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1928. 2 males.

DISTRIBUTION: Little Ki Island and above locality.

Genus COSMONOTUS ADAMS and WHITE.

171. Cosmonotus grayii ADAMS and WHITE.

ADAMS and WHITE, 1848, p. 60, Pl. 13, Fig. 3; HENDERSON, 1888, p. 33; DOFLEIN, 1904, p. 51, Pl. 18, Figs. 5-8; STIMPSON, 1907, p. 181.

LOC. Station 238, south of Misaki, 106 m. deep. November 6, 1927. 1 male.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 female.

Station 300, east of Kagosima-ken, 110 m. deep. July 11, 1928. 2 females, 1 bears eggs.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 male.

Station 348, Kii Strait, 106 m. deep. July 21, 1928. 1 male.

Station 360, south of Owase, Mie-ken, 123 m. deep. August 9, 1928. 1 female.

Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 female.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 male.

Station 465, north of Gotô Isls., west of Hirato, 106 m deep. July 24, 1929. 1 male and 1 female.
Station 468, east of Tusima Isl., 112 m. deep. July 25 1929. 1 male.
Station 483, north of Nagato, Yamaguti-ken, 130 m. deep August 9, 1929. 2 males.
Station 484, north of Nagato, Yamaguti-ken, 93 m. deep August 9, 1929. 1 male and 1 female.
Station 485, east of Misima Isl., 93 m. deep. August 11 1929. 1 male.
Station 493, off Hamada, Simane-ken, 124 m. deep. Augus 12, 1929. 1 female.
Station 520, north of Mihonoseki, Simane-ken, 75 m. deep August 23, 1929. 1 male.
Station 521, between Oki Isls. and Mihonoseki, 86 m deep. August 23, 1929. 1 female.

DISTRIBUTION: Dar-es-Salaam; Amboina; Persian Gulf; Borneo north of Formosa; from Japanese waters not hitherto been known.

Family **Calappidae** DANA.

Genus **MURSIA** DESMAREST.

172. Mursia armata DE HAAN.

DE HAAN, 1839, p. 73, Pl. 19, Fig. 2; ORTMANN, 1892, p. 564; DOFLEIN, 1902, p. 653; 1904, p. 40, Pl. 17, Fig. 1, Pl. 18, Fig. 2; PARISI 1914. p. 290; BALSS, 1922, p. 124.

LOC. Station 305, Bungo Strait, 137 m. deep. July 12, 1928. : males.
Station 406, south of Kôti, 97 m. deep. May 3, 1928. : females.
Station 408, coast of Kôti-ken, 88 m. deep. December 7 1928. 1 male.
Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 1 male.

DISTRIBUTION: China; Japan: Tokyo Bay, Sagami Bay and above localities.

173. Mursia armata curtispina MIERS.

MIERS, 1886, p. 291, Pl. 24, Fig. 2; DOFLEIN, 1904, p. 40, Pl. 17, Fig. 2, Pl. 18, Fig. 3; BALSS, 1922, p. 124.
Mursia aspcra, ALCOCK, 1899, p. 24.
Mursia armata trispinosa, PARISI, 1914, p. 290, Pl. 12.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 1 male.

Station 179, south of Irô-zaki, 187 m. deep. June 28, 1927. 1 female.

Station 198, south-east of Toba, Mie-ken, 168 m. deep. July 4, 1927. 2 males and 3 females.

Station 199, south of Toba, Mie-ken, 207 m. deep. July 11, 1927. 4 males.

Station 207, east of Siwo-misaki, 229 m. deep. July 13, 1927. 1 female.

Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 male and 3 females.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 2 females.

Station 220, west of Muroto-zaki, 234 m. deep. July 19, 1927. 1 male.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 male.

Station 223, south of Koti, 311 m. deep. July 20, 1927. 1 male.

Staiton 259, Suruga Bay, 188 m. deep. November 15, 1927. 1 male.

Station 276, near Omae-zaki, 77 m. deep. July 2, 1928. 2 males and 1 female.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 female.

Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 2 males and 1 female.

Station 283, between Omae-zaki and Irô-zaki, 177 m. deep. July 4, 1928. 1 male.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 male and 1 female.

Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 male.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 male.

Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1 male.

Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 male.

Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 female.

Station 388, south of Lake Hamana, 136–189 m. deep. December 12, 1928. 1 male.

Station 434, south of Gotô Isls., 238 m. deep. July 18, 1929. 2 males.

Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 3 males.

Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 2 males and 2 females.

Station 451, west of Gotô Isls., 187 m. deep. July 22, 1929. 5 males and 1 females.

Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 2 females.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 male.

Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 male.

Station 553, north of Mikuni, Hukui-ken, 113 m. deep. July 21, 1930. 1 female.

In the specimens from Stations 198, 434 and 483, the lateral tooth of the carapace is somewhat longer than that of the other.

DISTRIBUTION: Fiji Islands; Nias Islands; Maladive Island; Japan: Tokyo Bay, Sagami Bay and above localities. In Japanese localities, depth: 77–311 m.

Gamily **Leucociidae** DANA.

Genus **OREOPHORUS** RÜPPELL.

174. ***Oreophorus rugosus*** STIMPSON.

STIMPSON, 1858, p. 161; 1907, p. 159, Pl. 19, Fig. 16; ORTMANN, 1892, p. 575; IHLE, 1918, p. 212, Fig. 121.

LOC. Station 299, east of Kagosima-ken, 115 m. deep. July 11, 1928. 1 female.

Carapace 9.3 mm. long, 11.5 mm. broad and front 2.3 mm. wide.

DISTRIBUTION: Mauritius Island; Australia; Siam; Cochin China; Christmas Island; New Caledonia; Loochoo; Japan: Kagosima.

Genus **CRYPTOCNEMUS** STIMPSON.

175. Cryptocnemus obolus ORTMANN.

(Text-fig. 40.)

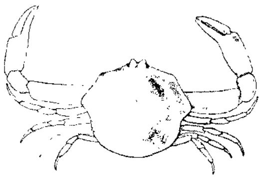
ORTMANN, 1892, p. 576, Pl. 26, Fig. 12; IHLE, 1918, p. 286.

LOC. Station 301, east of Ariake Bay, Kagosima-ken, 181 m. deep. July 12, 1928. 1 male.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 3 males.

Tooth on the pterygostomian region not so prominent as that figured by the author.

DISTRIBUTION: Sulu Islands; Japan: Sagami Bay and above localities.



Text-fig. 40. *Cryptocnemus obolus* ORTMANN (×5)

Genus **EBALIA** LEACH.

176. Ebalia scabriscula ORTMANN.

ORTMANN, 1892, p. 580, Pl. 26, Fig. 14; BALSS, 1922, p. 127.

LOC. Station 251, Sagami Bay, 165 m. deep. November 9, 1927. 1 male.

Station 273, Suruga Bay, 123 m. deep. July 2, 1928. 1 female.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 male.

Station 290, east of Omae-zaki, 143 m. deep. July 5, 1928. 1 female.

Station 301, east of Kagosima-ken, 181 m. deep. July 12, 1928. 1 male.

Station 307, Bungo Strait, 165 m. deep. July 14, 1928. 1 egg-bearing female.
Station 332, south of Asizuri-zaki, 658 m. deep. July 22, 1928. 1 female.
Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 1 male.
Station 465, north of Gotô Isls., west of Hirato, 106 m. deep. July 24, 1929. 1 male and 1 egg-bearing female.

Front distinctly divided into two lobes. Tubercle on the intestinal region somewhat more prominent. The cheliped is longer than that described by ORTMANN. Posterior pereiopods cylindrical, but merus, carpus and propodus almost smooth. Abdomen of male as well as of female four-segmented, but in male the penultimate segment is provided with a pointed tubercle near the distal end.

DISTRIBUTION: Japan: Sagami Bay and above localities. Depth: 106–658 m.

177. *Ebalia longimana* ORTMANN.

ORTMANN, 1892, p. 579, Pl. 26, Fig. 13.
Ebalia gotoensis, RATHBUN, 1932, p. 36.

LOC. Station 220, west of Muroto-zaki, 234 m. deep. July 19, 1927. 1 female.
Station 239, south of Misaki, 307 m. deep. November 6, 1927. 1 male.
Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1 female.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 3 males.
Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 male and 1 female.
Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 egg-bearing female.
Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 2 males.
Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 male.
Station 465, north of Gotô Isls., west of Hirato, 106 m. deep. July 24, 1929. 1 male.

Station 469, between Simonoseki and Tusima Isl., 91 m. deep. July 25, 1929. 1 male.
Station 471, north-west of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 male.
Station 546, Wakasa Bay, 101 m. deep. July 20, 1930. 1 egg-bearing female.

In some specimens, the chelipeds are somewhat shorter than that described by ORTMANN.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Maizuru, Gotô Isls. and above localities. Depth: 51–307 m.

178. *Ebalia japonica* RATHBUN.

RATHBUN, 1932, p. 37.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 59 males and 31 females, some bear eggs.
Station 76, south of Siwoya-zaki, 128 m. deep. July 21, 1926. 1 egg-bearing female.
Station 90, north of Todo-saki, 152 m. deep. November 3, 1926. 1 female.
Station 119, between Siwoya-zaki and Inuboe-zaki, 124 m. deep. March 4, 1927. 1 male.
Station 120, south of Siwoya-zaki, 141 m. deep. March 4, 1927. 1 male.
Station 126, between Kinkazan and Siwoya-zaki, 146 m. deep. March 7, 1927. 1 male.
Station 139–140, east of Kinkazan, 320–344 m. deep. November 24, 1925. 2 females.
Station 188, south-east of Omae-zaki, 214 m. deep. June 30, 1927. 2 egg-bearing females.
Station 209, west of Siwo-misaki, 256 m. deep. July 13, 1927. 1 male.
Station 220, west of Muroto-zaki, 234 m. deep. July 19, 1927. 1 male.
Station 223, south of Kôti, 311 m. deep. July 20, 1927. 1 female.
Station 251, Sagami Bay, 165 m. deep. November 9, 1927. 1 female.
Station 255, north-east of Simoda, 263 m. deep. November

10, 1927. 1 male and 1 female.

Station 273, off Hamana Lake, 123 m. deep. July 2, 1928. 1 female.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 3 males.

Station 304, Bungo Strait, 241 m. deep. July 12, 1928. 2 males.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 male and 1 egg-bearing female.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 2 males and 1 female.

Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1 male.

Station 360, south of Owase, Mie-ken, 123 m. deep. August 9, 1928. 1 female.

Station 419, south of Kosiki Isls., 402 m. deep. July 15, 1929. 2 males and 1 egg-bearing female.

Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 1 male.

Station 461, west of Tusima Isl., 120 m. deep. July 24, 1929. 1 egg-bearing female.

Station 485, east of Misima Isl., 93 m. deep. August 11, 1929. 1 male.

Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 male.

Station 553, north of Mikuni, Hukui-ken, 113 m. deep. July 21, 1930. 1 male and 1 female.

Station 580, Toyama Bay, 135 m. deep. July 29, 1930. 1 male and 1 egg-bearing female.

Station 582, Toyama Bay, 176 m. deep. July 30, 1930. 2 males and 1 female.

Station 587, Toyama Bay, 97 m. deep. August 2, 1930. 1 female.

Station 588, coast of Toyama-ken, 219 m. deep. August 2, 1930. 1 female.

Station 599, near Sado Isl., 181 m. deep. August 9, 1930. 3 males.

Station 618, off mouth of the River Mogami, 135 m. deep. August 14, 1930. 2 males.

Station 638, west of Tubaki-zaki, Aomori-ken, 73 m. deep. August 18, 1930. 6 males.
Station 645, west of Lake Zyûsan-gata, Aomori-ken, 115 m. deep. August 22, 1930. 4 males.
Station 647, west of Lake Zyûsan-gata, Aomori-ken, 86 m. deep. August 23, 1930. 1 male.
Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 4 males and 2 females.
Station 653, Tugaru Strait, 108 m. deep. August 24, 1930. 1 male.
Station 658, Tugaru Strait, 113 m. deep. August 30, 1930. 2 males and 1 female.

It is near *Ebalia salamensis* DOFLEIN (1904, p. 47, Pl. 16, Figs. 1–3), but the front is not so sharply truncated as that in the figure given by DOFLEIN, and the granules on the surface are somewhat weak in the specimen.

DISTRIBUTION: Japan: off Niigata and above localities. Depth: 73–402 m.

179. Ebalia jordani RATHBUN.

RATHBUN, 1606, p. 889, Pl. 15, Fig. 3.

LOC. Station 179, near Irô-zaki, 187 m. deep. June 28, 1927. 1 female.

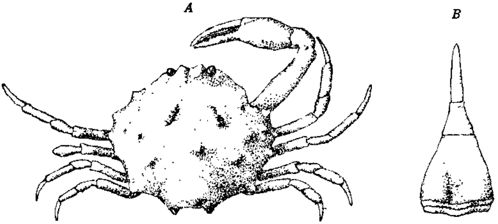
DISTRIBUTION: Hawaii and above locality.

180. Ebalia tuberculata n. sp.

(Text-fig. 41.)

LOC. Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 egg-bearing female.
Station 220, west of Muroto-zaki, 234 m. deep. July 19, 1927. 1 male.
Station 232, south-east of Muroto-zaki, 269 m. deep. July 30, 1927. 1 male and 1 female.
Station 326, Bungo Strait, 393 m. deep. July 21, 1928. 1 male.
Station 417, south of Satuma, Kagosima-ken, 192 m. deep. July 14, 1929. 1 female.

Station 428, north of Kosiki Isls., west of Amakusa Isls., 119 m. deep. July 16, 1929. 1 female.



Text-fig 41. *Ebalia tuberculata* n. sp.
A, Entire animal of a female from Station 417 (×2).
B, Abdomen of male (×4).

Carapace convex, broader than long, minutely granular and provided with some tubercles on the surface. Front two-lobed. Behind the orbital angle there are six marginal tubercular teeth on each side; in these tubercular teeth at the third one the carapace is broadest and the last one is on the posterior margin. On the dorsal surface two tubercles are on the medial line, the anterior cardiac and the posterior intestinal ones. The cardiac tubercle is near the middle of the carapace. An obliquely elongated tubercle, which is in some specimens divided into two round tubercles, is on the gastric region, another round one on the hepatic and three are on the branchial region. The pterygostomian tubercle, which is noticeable in dorsal view, is continuous to the outer anterior corner of the buccal area as an obtuse ridge.

Two pairs of the antennae are comparatively well developed. The antennular fossa is communicated with the orbit. In the external maxilliped, the exognath is nearly as wide as the endognath; in the latter the merus is a little shorter than the basiischium measuring along the inner border. Chelipeds subequal; palm shorter than finger. Succeeding four legs subcylindrical and almost subequal in length, but first longer and successively diminished in length to the posterior leg.

The abdomen in male consists of five segments: the proximal two are very short, the third is longer and broader than any of

others. The terminal segment is long and narrow, terminally rounded. In the female, it is four-segmented.

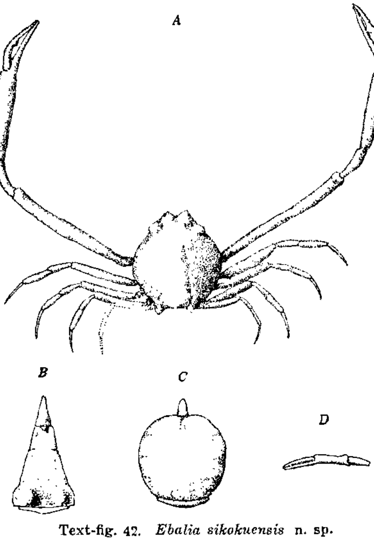
181. Ebalia sikokuensis n. sp.

(Text-fig. 42.)

Loc. Station 331, south-west of Asizuri-zaki, 344 m. deep. July 22, 1928. 3 males and 1 female.

The species is referable to the present genus, though there are some doubts.

Carapace nearly as long as broad; front bilobed, emarginate; orbit small; hepatic region expanded; on each side of the posterior margin there is a tubercle, and one more on the medial line.



Text-fig. 42. *Ebalia sikokuensis* n. sp.
A, Entire animal of male (×3). *B*, Abdomen of male (×5). *C*, Abdomen of female (×5). *D*, Chela of female (×3).

The latter is a little above the level of the lateral ones. Surface moderately convex, finely granulated. In the external maxilliped, the exognath is nearly as wide as the endognath, in which the merus is as long as the basiischium in the inner margin. Legs subcylindrical. The cheliped is very long in the male and the palm of the chela is a little longer than one and a half times the length of the finger. The proximal half of the movable finger is arcuate inwards and devoid of teeth on the inner margin, while the terminal half is nearly straight, and on the inner margin there are a prominent tooth and a number of small ones. The immovable finger is a little bent outwards at the base, but distally nearly straight, leaving a wide gape at the base between the movable finger. In the female, the cheliped is not so long as that of the male, and the finger is nearly as long as the palm. Both fingers are straight, leaving no space between them, when they are closed. Posterior abdomen consists of four segments in male, while in the female it is three-segmented.

182. Ebalia rugosa n. sp.

(Text-fig. 43.)

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 3 females.
Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 1 female.
Station 266, Suruga Bay, 128 m. deep. November 18, 1927. 1 female.
Station 283, between Omae-zaki and Irô-zaki, 177 m. deep. July 4, 1928. 1 male and 1 female.
Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 female.
Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 1 female.
Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

The species seems to be variable in the relative dimension. Description of the male specimen from Station 440:

Carapace subtriangular, a little broader than one and one-fourth of the length. It is rugose and granular. The median cardiac tubercular carina terminates in a point above the posterior margin. Just

in front of this carina on the protogastric region, there is a pair of tubercular masses, which are pointed anteriorly. From each of this tubercular masses an obtuse but strong carina runs outwards and backwards as to form the basal angle of the triangle of the carapace. The front is shallowly bifid and the dorsal surface is slightly furrowed in the middle line. On the pterygostomian region there is a sharp tubercle. On the basal line of the triangle of the carapace there is a pair of prominences, which are tubercles on the posterior margin of the carapace.

Text-fig. 43. *Ebalia rugosa* n. sp. (×3).

In the specimen from Station 431, the carapace is not so laterally dilated as that of the specimen above described and it is a little broader than long, so that the carapace is subhexagonal in shape. The tubercles and tubercular processes on the carapace are much less prominent.

Legs are also tubercular surfaced; chelipeds subequal, chela a little compressed. The following legs rather stout.

Genus PRAEBEBALIA RATHBUN.

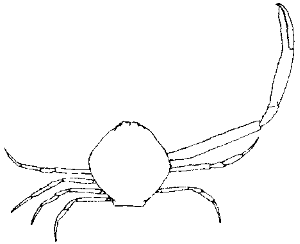
183. Praebebalia longidactyla n. sp.

(Text-fig. 44.)

LOC. Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male.
Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 male.
Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 male and 1 female.
Station 451, west of Gotô Isls., 187 m. deep. July 22, 1929. 1 male and 1 female.

Near *P. pisiformis* IHLE (1918, p. 233, Fig. 130). Body smooth, naked. Carapace moderately convex, nearly as wide as long, roughly hexagonal. Front produced somewhat more than that of *P. pisiformis*. Chelipeds very long; finger one and one-fourth as long as palm.

Posterior legs slender; dactylus much longer than propodus. Abdomen in both sexes four-segmented; basal linear, third the longest and with three tubercles in male.



Text-fig. 44. *Praebebalia longidactyla* n. sp. (×3)

Dimension of the male specimen from Station 451:

Length and width of carapace	5.5 mm.
Length of cheliped	17.0

Genus **Myra** Leach.

184. Myra fugax (Fabricius).

Myra fugax, (Fabr.) de Haan, 1841, p. 134; Ortmann, 1892, p. 581; Alcock, 1896, p. 204; de Man, 1907, p. 397; Parisi, 1914, p. 295; Ihle, 1918, p. 256; Balss, 1922, p. 127.
Persephona fugax, Rathbun, 1910, p. 308; 1911, p. 201.

Loc. Northern Japan Sea. August 1930. 1 female.

Distribution: Widely distributed in Indo-Pacific Region. Japan: to Sagami Bay.

Genus **Leucosia** Fabricius.

185. Leucosia rhomboidalis de Haan.

de Haan, 1841, p. 134, Pl. 33, Fig. 5; Alcock, 1896, p. 234; de Man, 1907, p. 397, Pl. 31, Fig. 7; Ihle, 1918, p. 282; Balss, 1922, p. 127.
Leucosia maculata, Stimpson, 1907, p. 150, Pl. 18, Fig. 2.

Loc. Northern Japan Sea. August 1930. 2 males and 3 egg-bearing females.

DISTRIBUTION: Ceylon; Coromandel Coast; Andamans Archipelago; Hongkong; Japan: Nagasaki, Inland Sea, Maizuru and above locality; Vladivostock.

186. Leucosia longifrons DE HAAN.

DE HAAN, 1841, p. 132, Pl. 33, Fig. 4; ORTMANN, 1892, p. 585; PARISI, 1914, p. 293; BALSS, 1922, p. 128.
L. pulcherrima, MIERS, 1876, p. 236, Pl. 38, Figs. 4-6; HASWELL, 1882, p. 119.

LOC. Station 115, near Inuboe-zaki, 18 m. deep. March 3, 1927. 1 male and 1 female.
Uwazima, Ehime-ken, market, December 1, 1928. 1 female.
Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 2 males and 1 egg-bearing female.

DISTRIBUTION: Gulf of Persia; Ceylon; Andamans; Mergui Archipelago; Eastern Australia; New Caledonia; Japan: from Tokyo Bay to Kagosima, Nagasaki, Niigata and above locality.

187. Leucosia obtusifrons DE HAAN.

DE HAAN, 1841, p. 133, Pl. 33, Fig. 2; ALCOCK, 1896, p. 216; DOFLEIN, 1902, p. 654; PARISI, 1914, p. 291, Pl. 13, Fig. 4; BALSS, 1922, p. 128.

LOC. Station 238, south of Misaki, 106 m. deep. November 6, 1927. 1 male.
Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 male.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male.
Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 male.
Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 2 males and 1 egg-bearing female.
Station 293, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 1 female.
Station 308, southern Bungo Strait, 155 m. deep. July 14, 1928. 1 male.
Station 349, Kii Strait, 152 m. deep. August 1, 1928. 2 males.
Station 405, north-east of Ariake Bay, Kagosima-ken, 136 m. deep. May 5, 1928. 1 male.

Station 417, south of Satuma, Kagosima-ken, 192 m. deep. July 14, 1929. 1 male.

Station 422, west of Satuma, Kagosima-ken 88 m. deep. July 15, 1929. 3 males.

Station 426, north of Kosiki Isls., 99 m. deep. July 16, 1929. 1 male.

Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 1 male.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 male and 1 egg-bearing female.

Station 464, between Tusima Isl. and Gotô Isls., 146 m. deep. July 24, 1929. 1 male and 1 egg-bearing female.

Station 465, north of Gotô Isls., west of Hirato, 106 m. deep. July 24, 1929. 2 males.

Station 468, west of Iki Isl., 112 m. deep. July 25, 1929. 1 male.

Station 484, north of Nagato, Yamaguti-ken, 93 m. deep. August 9, 1929. 1 male and 2 females, 1 bears eggs.

Station 485, east of Misima Isl., 93 m. deep. August 11, 1929. 2 males.

DISTRIBUTION: Ceylon; Coromandel Coast; Japan: Tokyo Bay, Sagami Bay and above localities. Depth: to 300 m.

188. *Leucosia haematosticta* ADAMS et WHITE.

ADAMS and WHITE, 1848, p. 54, Pl. 12, Fig. 2; ALCOCK, 1896, p. 229; STIMPSON, 1907, p. 152.

LOC. Station 317, coast of Miyazaki-ken, 97 m. deep. July 16, 1928. 1 egg-bearing female.

Carapace a little longer than broad and roughly pentagonal. Front truncated, a little convex. Antero-lateral margin sinuated, obtusely angulate at lateral angle. Surface smooth, strongly convex, and rather high in the medial line especially in front of carapace, where obtusely carinate. Dimension of the female:

Length of carapace		12.1 mm.
Width of carapace		11.2
Cheliped:	Length of merus	5.2
	Length of palm	4.0
	Length of finger	4.0

DISTRIBUTION: India; Siam; Japan: Kagosima Bay and above locality.

189. Leucosia australiensis MIERS.

MIERS, 1886, p. 322, Pl. 27, Fig. 1.

LOC. 'Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 1 male.

Granules seem to be somewhat obscure, front more prominent than that of the type specimen. In other respects it agrees with the description and the figure.

DISTRIBUTION: Australia; no one hitherto been known from Japanese waters.

Genus PARIPHICULUS ALCOCK.

190. Pariphiculus coronatus ALCOCK et ANDERSON.

(Text-fig. 45.)

ALCOCK and ANDERSON, 1896, p. 174, Pl. 24, Fig. 2; ALCOCK, 1899, p. 30; DOFLEIN, 1904, p. 41, Pl. 14, Fig. 7; BALSS, 1915, p. 14; 1922, p. 131; IHLE, 1918, p. 249.

LOC. Station 188, south-east of Omae-zaki, 214 m. deep. June 30, 1927. 1 female.
Station 244, Sagami Bay, 135 m. deep. November 8, 1927. 1 female.
Station 313, Bungo Strait, 214 m. deep. July 15, 1928. 3 females, 1 bears eggs.
Station 464, between Tusima Isl. and Gotô Isls., 146 m. deep. July 24, 1929. 1 male.

Body densely covered with short hairs, and scarcely noticeable spinules on the carapace. Abdomen seven-segmented.

DISTRIBUTION: Red Sea; Bay of Bengal; Large Nicobar; Sumbawa Island; Japan: Tokyo Bay, Sagami Bay and above localities.

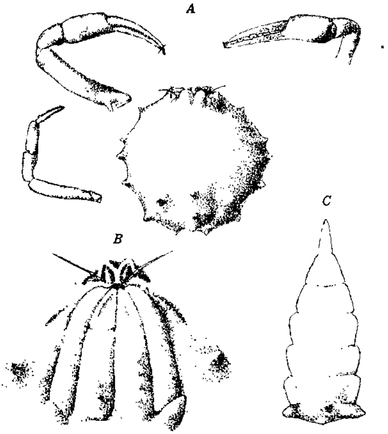
191. Pariphiculus agariciferus IHLE.

IHLE, 1918, p. 250, Fig. 136; BALSS, 1922, p. 131.

LOC. Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1928. 1 male and 1 female.

Station 221, north-west of Muroto-zaki, 209 m. deep. July 20, 1927. 1 male.

DISTRIBUTION: Timor; Rotti; Japan: above localities.



Text-fig. 45. *Pariphicus coronatus* ALCOCK et ANDERSON. *A*, Carapace and legs (×2). *B*, Buccal area (×6). *C*, Abdomen of male (×5).

Genus **RANDALLIA** STIMPSON.

192. Randallia japonica n. sp.

(Text-fig. 46.)

LOC. Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 female.

Station 267, Suruga Bay, 64 m. deep. November 18, 1927. 2 males and 3 egg-bearing females.

Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 male and 1 female.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male.

Station 300, west of Ariake Bay, Kagosima-ken, 110 m.

deep. July 11, 1928. 1 female.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 female.

Station 422, west of Kagosima-ken, 88 m. deep. July 15, 1929. 1 male.

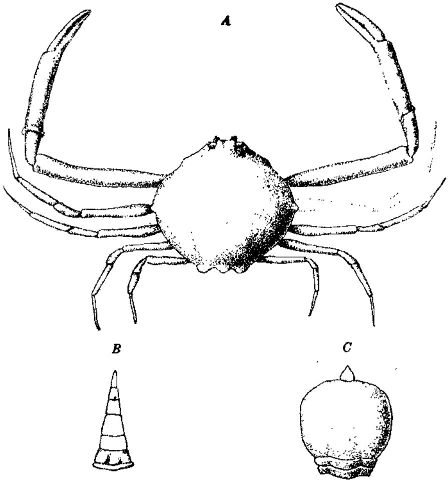
Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

Station 447, near Gotô Isls., 90 m. deep. July 20, 1929. 1 female.

Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 2 males and 1 female.

Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 3 males.

Station 462, south of Tusima Isl., 117 m. deep. July 24,



Text-fig. 46. *Randallia japonica* n. sp.
A, Entire animal (×2). *B*, Abdomen of male (×2).
C, Abdomen of female (×2).

1929. 1 female.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 male and 2 females.

Station 464, between Tusima Isl. and Gotô Isls., 146 m. deep. July 24, 1929. 2 males.

Station 467, north-east of Tusima Isl., 110 m. deep. July 25, 1929. 1 egg-bearing female.

Station 470, between Simonoseki and Iki Isl., 73 m. deep. July 25, 1929. 1 male.

Station 471, north of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 male.

Station 483, north of Tusima Isl., 130 m. deep. August 9, 1929. 1 male.

Carapace round, strongly convex, surface smooth; three round tubercles on posterior margin, and one more on the lateral margin. Front truncated in dorsal view, but it is deflexed in the middle so that there is a longitudinal sulcus in the middle line. The orbit is round, provided with two fissures on the dorsal margin and with a wide one on the ventral; the antennal fossa is communicated with this orbit.

Two pairs of the antennae are relatively well developed. The endognath of the external maxilliped is provided with a longitudinal piliferous ridge, and its merus a little shorter than the basiischium measuring along the inner margin. Chelipeds subequal; surface smooth. Succeeding legs slender, similar in feature; anterior one the longest and successively diminishing in length to the posterior one. The abdomen, in the male, is triangular in shape, six-segmented; in the female it is four-segmented, the penultimate joint is the largest.

No species of this genus has been reported from Japanese waters.

Genus ARCANIA LEACH.

193. Arcania undecimspinosa DE HAAN.

DE HAAN, 1841, p. 135, Pl. 33, Fig. 8; ORTMANN, 1892, p. 577; ALCOCK, 1896, p. 266; RATHBUN, 1902, p. 30; PARISI, 1914, p. 296; IHLE, 1918, p. 265; BALSS, 1922, p. 132.

LOC. Station 266, Suruga Bay, 128 m. deep. November 18, 1927. 1 female.

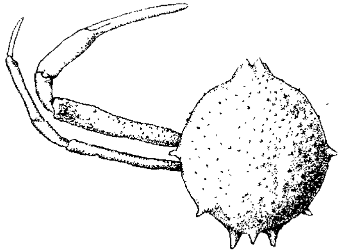
Station 267, Suruga Bay, 64 m. deep. November 18, 1927. 1 female.
Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 male and 1 egg-bearing female.
Station 360, south of Owase, Mie-ken, 123 m. deep. August 9, 1928. 1 male.
Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 2 females.
Station 451, west of Gotô Isls., 187 m. deep. July 22, 1929. 1 male.
Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 1 female.
Station 540, near Kyô-gasaki, 123 m. deep. August 25, 1929. 1 male.

DISTRIBUTION: Indian Ocean; east coast of Australia; Sulu Sea; Japan; Tokyo Bay, Sagami Bay, Inland Sea and above localities.

193a. Arcania undecimspinosa DE HAAN. var. *elongata* n. var.

(Text-fig. 47.)

LOC. Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 female.
Station 409, between Kôti and Asizuri-zaki, 77 m. deep. December 7, 1928. 1 female.
Mimase, Kôti-ken, market, December 12, 1928. 1 male.



Text-fig. 47. *Arcania undecimspinosa* var. *elongata* n. var. (×1.5).

Near preceding species. Carapace oval, distinctly longer than *broad; surface with high tubercular granules.* Two spinular tubercles on the antero-lateral margin very small. Colour in spirit gray. In other respects it agrees with the typical form.

194. Arcania globata STIMPSON.

STIMPSON, 1907, p. 156, Pl. 18, Fig. 9; MIERS, 1879, p. 44; ORTMANN, 1892, p. 577; DE MAN, 1907, p. 400, Pl. 31, Figs. 11-13; BALSS, 1922, p. 132.

LOC. Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1 male.
Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 male.
Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 1 male.
Station 469, between Simonoseki and Tusima Isl., 91 m. deep. July 25, 1929. 1 male.
Station 484, north coast of Nagato, Yamaguti-ken, 93 m. deep. August 9, 1929. 1 male and 1 female.

DISTRIBUTION: China Sea; Korea Canal; Maizuru; Inland Sea; Sagami Bay and above localities.

TRIBE CANCRIDEA.

SUBTRIBE OXYRHYNCHEA.

Family **Inachidae** MIERS.

Subfamily Leptopodiinae MIERS.

Genus ACHAEUS LEACH.

195. Achaeus japonicus (DE HAAN).

Inachus (Achaeus) japonicus, DE HAAN, 1835, p. 99, Pl. 22, Fig. 3.
Achaeus japonicus, MIERS, 1886, p. 9; ORTMANN, 1893, p. 33; STIMPSON, 1907, p. 20; URITA, 1926, p. 30.

LOC. Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 female.
Station 462, south of Tusima Isl., 117 m. deep. July 24, 1929. 1 egg-bearing female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Kôbe, Kagosima, Nagasaki and above localities.

196. *Achaeus tuberculatus* MIERS.

MIERS, 1879, p. 25; ORTMANN, 1893, p. 34; RATHBUN, 1894, p. 47; PARISI, 1915, p. 281, Fig. 1.

LOC. Station 81, south of Siriya-zaki, 172 m. deep. November 1, 1926. 1 egg-bearing female.

Station 112, south of Inuboe-zaki, 37 m. deep. March 2, 1927. 1 male and 1 female.

Station 115, south-west of Inuboe-zaki, 18 m. deep. March 3, 1927. 3 males.

Station 276, near Omae-zaki, 77 m. deep. July 2, 1928. 1 egg-bearing female.

Station 285, east of Omae-zaki, 71 m. deep. July 4, 1928. 1 male.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 male.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 male and 1 egg-bearing female.

Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 egg-bearing female.

Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 egg-bearing female.

Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1929. 2 males.

Station 461, west of Tusima Isl., 120 m. deep. July 24, 1929. 1 egg-bearing female.

Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 1 male.

Station 470, between Simonoseki and Iki Isl., 37 m. deep. July 25, 1929. 1 female.

Station 484, north of Nagato, Yamaguti-ken, 93 m. deep. August 9, 1929. 1 female.

Station 485, east of Misima Isl., 93 m. deep. August 11, 1929. 2 males.

Station 543, entrance of Wakasa Bay, 229 m. deep. July 18, 1930. 1 egg-bearing female.

Station 572, north of Noto, 132 m. deep. July 27, 1930. 2 egg-bearing females.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Kagosima,

Maizuru and above localities. Station 81 is the northern limit. Depth: to 229 m.

197. Achaeus spinosus MIERS.

MIERS, 1879, p. 25.

LOC. Station 179, near Irô-zaki, 187 m. deep. June 28, 1927. 1 female.
Station 239, south of Misaki, 307 m. deep. November 6, 1927. 1 male.
Station 251, Sagami Bay, 165 m. deep. November 9, 1927. 1 egg-bearing female.
Station 276, near Omae-zaki, 77 m. deep. July 2, 1928. 1 male.
Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 2 males.
Station 428, between Nagasaki and Kosiki Isl., 119 m. deep. July 16, 1929. 1 male.
Station 446, west of Gotô Isls., 117 m. deep. July 20, 1929. 1 egg-bearing female.

DISTRIBUTION: Japan: Mie-ken and above localities.

198. Achaeus stenorhynchus RATHBUN.

RATHBUN, 1923, p. 29.

LOC. Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 male and 1 female.
Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 1 male.

DISTRIBUTION: Japan: north-west of Gotô Isls. and above localiies. Depth: 132–255 m.

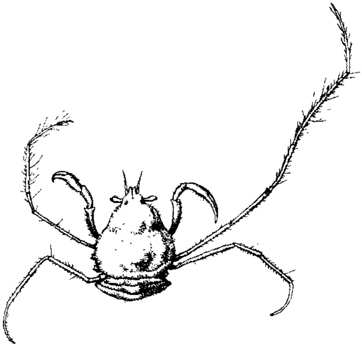
199. Achaeus robustus n. sp.

(Text-fig. 48.)

LOC. Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 egg-bearing female.

Carapace broad, a little longer than width; moderately convex, o spine on the dorsal surface; gastric, cardiac and branchial regions

elevated. Rostrum short, bifid and longitudinally sulcated. Eye-stalk of moderate length, not armed. Two pairs of antennae moderately well developed; basal article of outer antenna slender, ventrally



Text-fig. 48. *Achaeus robustus* n. sp. (×2)

flattened; its peduncle distinctly exceeds the rostrum.

Legs long and slender. Chelipeds in female subequal, shorter than succeeding legs; merus with a series of rather strong spines on the inferior margin; chela terminally curved inwards, finger longer than palm. Posterior four pairs of legs equally slender; second much longer than any of others, first the next and last a little shorter than third. In anterior two legs, dactyli styliform, while those of posterior two falciform.

Subfamily Inachinae MIERS.

Genus ONCINOPUS DE HAAN.

200. Oncinopus aranea DE HAAN.

DE HAAN, 1835, p. 100, Pl. 29, Fig. 2; MIERS, 1886, p. 20; ORTMANN, 1893, p. 39.

LOC. Station 271, south of Misaki, west of Suno-saki, 82 m. deep. November 18, 1926. 1 male.

DISTRIBUTION: South Australia; Arafura Sea; Molucca; Philippine; Japan: Kagosima and above locality.

Genus **PLEISTICANTHA** MIERS.

201. Pleisticantha moseleyi (MIERS).

Echinoplax moseleyi, MIERS, 1886, p. 32, Pl. 4, Fig. 2.
Echinoplax pungens, WOOD-MASON, 1891, p. 259.
Pleisticantha moseleyi, DOFLEIN, 1904, p. 76, Pl. 24, Figs. 5, 6, Pls. 25, 26.

LOC. Station 107, south of Inuboe-zaki, 115 m. deep. February 28, 1927. 2 males.
Station 109, south-east of Inuboe-zaki, 123 m. deep. March 2, 1927. 1 male and 1 female.
Station 221, north-west of Muroto-zaki, 209 m. deep. July 20, 1927. 1 egg-bearing female.
Station 270, Sagami Bay, 91 m. deep. November 18, 1927. 1 male and 1 female.
Station 318, Bungo Strait, 324 m. deep. July 16, 1928. 1 male.
Station 410, south of Kosiki Isls., 139 m. deep. April 25, 1928. 1 female.

DISTRIBUTION: East coast of Africa; Andaman Sea; Philippine; rom Japanese waters it has not hitherto been known.

202. Pleisticantha sancti-johannis MIERS.

MIERS, 1879, p. 24, Pl. 1, Fig. 1; ORTMANN, 1893, p. 39; PARISI, 1915, p. 283.

LOC. Station 429, north of Kosiki Isls., west of Amakusa Isls., 223 m. deep. July 16, 1929. 1 female.
Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 male.

I examined another male specimen from the sea near Misaki.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Suruga Bay, ff Mie-ken and above localities.

Genus **PLEISTICANTHOIDES** n. gen.

Near *Pleisticantha*. Carapace triangular, moderately convex,

armed with pointed granules and long stout hairs. Rostrum short, composed with two horns, which are almost parallel, but not in contact with one another. Each of the rostral horns with two branches on the base; one reaching the level of the distal end of the rostral horns, is directed obliquely forwards and downwards, another smaller one is directed outwards. Eyes projecting outwards. Orbit not defined, inferior wall wanting. Supraorbital lobe finely serrated, and three teeth behind this. Inner antenna longitudinal; interantennular septum with a pair of spines, which are directed downwards and forwards. Outer antenna with the basal joint extremely slender and armed with three spines.

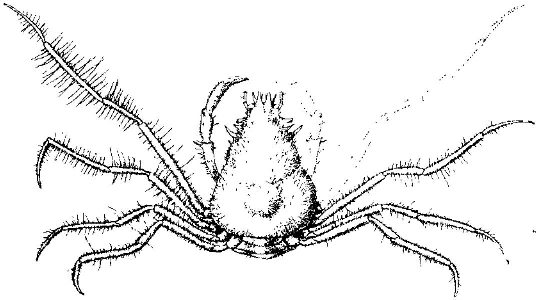
Legs long and slender; cheliped with merus and carpus spinulous, the second is the longest and successively diminishing in length to the posterior fifth pair.

The new genus differs from *Pleisticantha* in the shorter rostrum and the paired spines on the interantennular septum.

203. ***Pleisticanthoides nipponensis*** n. sp.

(Text-fig. 49.)

LOC. Station 109, south-east of Inuboe-zaki, 123 m. deep. March 2, 1927. 1 female.
Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1928. 1 female.



Text-fig. 49. *Pleisticanthoides nipponensis* n. sp. (×3)

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 male and 1 egg-bearing female.

A small tooth behind the postorbital tooth, and no one on the margin or on the surface. Gastric and cardiac region a little convex. In the chelipeds of female, the merus is armed with a spine on the inner margin and four on the outer margin; the carpus with four spines, two on the inner margin and the other two on the superior surface. Posterior four pairs of legs are provided with no spine. It is near *Pleisticantha simplex* RATHBUN (1932, p. 30).

Genus **PARAPLEISTICANTHA** n. gen.

Near *Oregonia* and *Pleisticantha*. Carapace subpyriform, moderately convex and spinulous. Rostrum short, two horns divergent. Outer antenna visible in dorsal view on each side of rostrum, basal joint narrow. Merus of external maxilliped produced to a point at antero-external angle, bearing the palp at its antero-internal angle. Legs hairy. Chelipeds short and nearly as wide as the succeeding pairs of legs in female. Postorbital spine not so prominent as that of *Oregonia*. Projection on the interantennular septum is near that of *Pleisticantha*.

204. Parapleisticantha japonica n. sp.

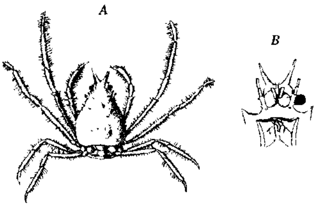
(Text-fig. 50.)

LOC. Station 189, south of Omae-zaki, 196 m. deep. July 1, 1927. 1 egg-bearing female.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 egg-bearing female.

Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 11, 1929. 3 females, 1 bears eggs.

Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 1 male and



Text-fig. 50. *Parapleisticantha japonica* n. sp.
A, Entire animal. Natural size.
B, Antennal and buccal region (×2).

1 egg-bearing female.

Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 2 egg-bearing females.

Carapace spinulous, short hairs at the bases of the spinules. Rostral horns somewhat longer than width at the base, distally divergent. Two spinules on supraorbital margin, three behind the eye, the last is the largest. Some smaller ones on the lateral magin. Gastric, cardiac and branchial regions a little convex. Five spinules on the gastric region are larger than others, one on the medial line. Two on the cardiac region. Chelipeds in male strong; the merus, the carpus and the palm are spinulous. The palm is rather stout and longer than the finger, which leaves a space gaping between the other at the base. Chela devoid of hairs. In the female, it is very weak and chela is hairy. Posterior legs are hairy; anterior two with merus spinulous. The species seem to be near *Pleisticantha terribilis* RATHBUN (1932, p. 30).

Genus OREGONIA DANA.

205. Oregonia gracilis DANA.

DANA, 1852, p. 106; atlas, 1855, Pl. 3, Fig. 2; RATHBUN, 1925. p. 71, Pls. 24, 25, Text-figs. 19, 20 (other previous literature and synonyms); YOKOYA, 1928, p 765.

LOC. Station 26, east of Siwoya-zaki, 232 m. deep. July 23, 1926. 1 male.

Station 36, south of Siriya-zaki, 128 m. deep. July 27, 1926. 1 egg-bearing female.

Station 45, between Todo-saki and Kinkazan, 349 m. deep. July 9, 1926. 1 male and 1 egg-bearing female.

Station 58, north-east of Todo-saki, 177 m. deep. July 18, 1926. 1 male and 1 egg-bearing female.

Station 59, north-east of Todo-saki, 168 m. deep. July 19, 1926. 2 egg-bearing females.

Station 61, north of Todo-saki, 170 m. deep. July 21, 1926. 1 female.

Station 66, between Siriya-zaki and Todo-saki, 165 m. deep. July 21, 1926. 2 males and 1 female.

Station 68, between Siriya-zaki and Todo-saki, 197 m.

deep. July 25, 1926. 2 males and 1 female.

Station 70, south-east of Siriya-zaki, 285 m. deep. July 26, 1926. 2 males.

Station 71, south-east of Siriya-zaki, 444 m. deep. July 26, 1926. 1 egg-bearing female.

Station 74, south of Siriya-zaki, 219 m. deep. July 27, 1926. 2 females, 1 bears eggs.

Station 83, between Siriya-zaki and Todo-saki, 55 m. deep. November 2, 1926. 1 male.

Station 88, north of Todo-saki, 135 m. deep. Novebmer 3, 1926. 1 male.

Station 90, near Todo-saki, 152 m. deep. November 6, 1926. 4 males and 6 females, 3 bear eggs.

Station 109, south-east of Inuboe-zaki, 123 m. deep. March 2, 1927. 1 male.

Station 128, south of Kinkazan, 48 m. deep. March 10, 1927. 1 male and 2 females.

Station 132, between Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 4 males and 1 female.

Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 1 male and 1 female.

Station 136–137, east of Kinkazan, 194-238 m. deep. March 12, 1925. 1 male.

Station 248, south of Kinkazan, 270 m. deep. August 3, 1925. 1 egg-bearing female.

Station 474, between Tusima Isl. and Huzan, 219 m. deep. July 28, 1929. 1 male.

Station 628, south-west of Oga, 148 m. deep. August 17, 1930. 1 male and 1 young female.

Station 647, west of Zyûsan-gata, 86 m. deep. August 23, 1930. 1 male.

Station 648, west of Tugaru Strait, 247 m. deep. August 23, 1930. 1 female.

Station 650, Tugaru Strait, 269 m. deep. August 23, 1930. 1 egg-bearing female.

Station 651, Tugaru Strait, 91 m. deep. August 23, 1930. 12 males and 9 females, 2 bear eggs and 4 youngs.

Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 17 males and 31 females, 15 bear eggs.

Station 655, Tugaru Strait, 112 m. deep. August 30, 1930. 1 male and 1 egg-bearing female.
Station 656, Tugaru Strait, 170 m. deep. August 30, 1930. 1 male and 1 female.
Station 658, Tugaru Strait, 113 m. deep. August 30, 1930. 3 females, 1 bears eggs.

DISTRIBUTION: From Bering Sea to California; on the western Pacific side, Simushir Isl. to Kinkazan and above localities. Station 109 is the southern limit on the Pacific side. On the side of Japan Sea, Station 474 is the southern limit, in the localities along the coast of Honsyû Station 628 is the southern limit as far as I know.

206. Oregonia mutsuensis YOKOYA.

YOKOYA, 1928, p. 766, Text-fig. 3.

LOC. Station 86, between Siriya-zaki and Todo-saki, 86 m. deep. November 2, 1926. 1 female.
Station 95, between Todo-saki and Kinkazan, 141 m. deep. November 7, 1926. 1 male and 1 female.
Station 146, east of Siwoya-zaki, 201 m. deep. November 30, 1925. 1 female.

DISTRIBUTION: Mutu Bay and above localities.

Genus HALIMUS LATREILLE.

207. Halimus kyusyuensis n. sp.

(Text-fig. 51.)

LOC. Station 292, west of Is. Tanegasima, 126 m. deep. July 10, 1928. 1 male.

The species is near *Halimus boradailei* RATHBUN[1]. Rostrum more divergent, horizontal and about two-thirds as long as rest of carapace. Regions fairly well defined, but almost smoothly surfaced. Anterior margin of postocular cup sinuated. Some very obscure tubercles on branchial region, and two more on each side of anterior gastric region. Two prominent tubercles on pterygostomian region. Chela with wide gape between fingers. Meri and dactyli of legs unarmed.

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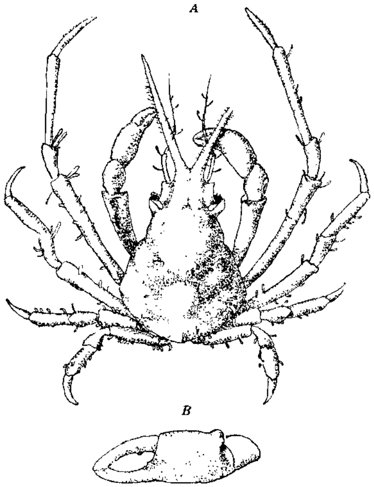
1) RATHBUN, 1911, p. 251, Pl. 20, Fig. 5.



Text-fig. 51. *Halimus kyusyuensis* n. sp.
A. Entire animal (×3). *B*. Chela of left side (×5).

Genus CYRTOMAIA MIERS.

208. *Cyrtomaia septemspinosa* RATHBUN.

RATHBUN, 1932, p. 30.

LOC. Station 4, east of Bôsyû, 287 m. deep. June 16, 1926. 2 females.

Station 366, south of Toba, Mie-ken, 494 m. deep. August 10, 1928. 1 female.

Station 382, east of Owase, Mie-ken, 180 m. deep. December 4, 1927. 1 male.

Station 416, south of Satuma, Kagosima-ken, 379 m. deep. July 14, 1929. 1 female.

Station 435, south of Gotô Isls., 324 m. deep. July 18, 1929. 1 male.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 3 males and 5 egg-bearing females.

Station 462, south of Tusima Isl., 117 m. deep. July 24, 1929. 1 male and 1 egg-bearing female.

Merus of fourth leg with a distal spine.

DISTRIBUTION: Japan: near Kosiki Islands and above localities. Depth: 117–710 m.

209. Cyrtomaia horrida RATHBUN.

RATHBUN, 1916, p. 532.

LOC. Station 189, far south of Omae-zaki, 196 m. deep. July 1, 1927. 1 female.

DISTRIBUTION: Philippine Islands; Japan is new distribution.

210. Cyrtomaia platypes n. sp.

(Text-fig. 52.)

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 1 egg-bearing female.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 female.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 male.

Station 293, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 1 female.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 egg-bearing female.

Station 325, Bungo Strait, 210 m. deep. July 21, 1928. 1 female.

Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 3 males.

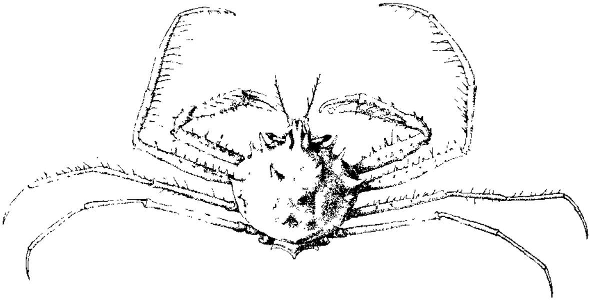
Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 1 male.

Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 1 male and 2 egg-bearing females.

Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 1 male.

The species is near *Cyrtomaia septemspinosa* and *C. lamellata*

RATHBUN (*1906, p. 879, Fig. 36*), but the two peduncular articles of the outer antenna are extremely flattened and the palm of the



Text-fig. 52. *Cyrtomaia platypes* n. sp. (×2)

chela is distinctly compressed. The eye-stalk is moderately long and armed with two small tubercles near the extremity. Anterior three legs are more or less armed with spinules and long setae, while the posterior two are smoothly surfaced and devoid of setae.

The teeth on the carapace are similarly arranged with those of *C. lamellata*, but in the branchial teeth the anterior is large and followed by two or three much smaller ones.

Genus **PSEUDOCOLLODES** RATHBUN.

211. Pseudocollodes demani BALSS.

(Text-fig. 53.)

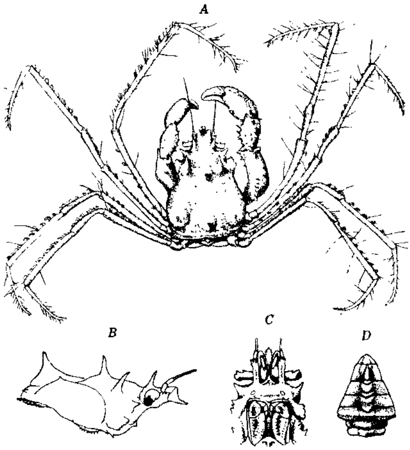
BALSS, 1929, p. 4, Fig. 2.

LOC. Station 107, south-west of Inuboe-zaki, 115 m. deep. February 28, 1927. 1 male.

The specimen referable to this species, differs in some respects from the description and the figure of the type specimen, but the differences are probably owing to the difference of sexes. In the following there is given a brief description of the present specimen.

The interantennular projection is provided with two short processes, one on each side, and seems to be not so prominent as that

shown in the figure given by BALSS. Chelipeds longer and stouter; spines on merus and carpus less prominent; palm stout and a little



Text-fig. 53. *Pseudocollodes demani* BALSS.
A, Entire animal (×2). *B*, Carapace from right side (×3). *C*, Antennal and buccal region (×3). *D*, Abdomen of male (×3).

compressed; fingers slender, nearly straight and not gaping between immovable finger.

Abdomen in male consists of seven segments, of which proximal two are tuberculated in the medial line, the third is the broadest and the following segments are successively diminished in width; the penultimate segment is provided with a sharply pointed tooth in the middle.

DISTRIBUTION: Japan: Sagami Bay and above locality.

Genus **MACROCHEIRA** DE HAAN.

212. Macrocheira kaempferi DE HAAN.

DE HAAN, 1835, p. 100, Pls. 25, 26, 28; ADAMS and WHITE, 1850, p. 5;

MIERS, 1886, p. 33; ORTMANN, 1893, p. 40; URITA, 1926, p. 32.
Kaempferia kaempferi, DOFLEIN, 1902, p. 653; PARISI, 1915, p. 285.

LOC. Station 398, near Owase, Mie-ken, 91 m. deep. February 29, 1928. 1 male and 1 egg-bearing female.

DISTRIBUTION: Japan: Sagami Bay, off Sizuoka-ken Kagosima and above locality. I have examined some specimens from Ibaragi-ken.

Subfamily Acanthorhynchinae MIERS.

Genus **PUGETTIA** DANA.

213. ***Pugettia quadridens*** (DE HAAN).

Pisa (Menaetius) quadridens, DE HAAN, 1838, p. 97, Pl. 24, Fig. 2.
Pugettia quadridens, STIMPSON, 1857, p. 219; 1907, p. 24; MIERS, 1879, p. 23; ORTMANN, 1893, p. 43; DOFLEIN, 1902, p. 656; PARISI, 1915, p. 285.

LOC. Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 young male.
Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 2 egg-bearing females.
Station 318, Bungo Strait, 324 m. deep. July 16, 1928. 1 male.
Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 2 egg-bearing females.
Station 654, Tugaru Strait, 44 m. deep. August 30, 1930. 2 males.

DISTRIBUTION: Tokyo Bay, Sagami Bay, Kagosima, Korea Strait, Niigata-ken, Otaru, Hokkaidô, and above localities.

214. ***Pugettia incisa*** (DE HAAN).

Pisa (Menacthius) incisa, DE HAAN, 1838, p. 98, Pl. 24, Fig. 3.
Pugettia incisa, MIERS, 1879, p. 23; 1886, p. 40; ORTMANN, 1893, p. 44: DOFLEIN, 1902, p. 656; STIMPSON, 1907, p. 24; PARISI, 1915, p. 286; YOKOYA, 1928, p. 768.

LOC. East of Honsyû, February 1927. 1 egg-bearing female.
Station 654, Tugaru Strait, 44 m. deep. August 30, 1930. 1 male and 1 female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Mikawa, Kagosima, Nagasaki, Korea Strait, Aomori, Hakodate.

215. Pugettia minor ORTMANN.

ORTMANN, 1893, p. 44; DOFLEIN, 1902, p. 656; PARISI, 1915, p. 286; YOKOYA, 1928, p. 768.

Loc. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 2 males and 1 egg-bearing female.

Station 12, east of Inuboe-zaki, 325 m. deep. June 23, 1926. 2 egg-bearing females.

Station 16, north-east of Inuboe-zaki, 530 m. deep. June 24, 1926. 1 male and 1 egg-bearing female.

Station 80, south of Siriya-zaki, 113 m. deep. November 1, 1926. 1 female.

Station 81, south of Siriya-zaki, 172 m. deep. November 1, 1926. 1 female.

Station 95, between Todo-saki and Kinkazan, 141 m. deep. November 7, 1926. 1 female.

Station 97, north of Kinkazan, 123 m. deep. November 7, 1926. 1 egg-bearing female.

Station 99, east of Kinkazan, 148 m. deep. November 8, 1926. 1 male.

Station 100, south-east of Kinkazan, 137 m. deep. November 8, 1926. 1 egg-bearing female.

Station 107, south of Inuboe-zaki, 115 m. deep. February 28, 1927. 1 male and 1 female.

Station 109, south-east of Inuboe-zaki, 123 m. deep. March 2, 1927. 2 males and 3 young females.

Station 111, south of Inuboe-zaki, 121 m. deep. March 2, 1927. 1 male.

Station 114, east of Inuboe-zaki, 95 m. deep. March 3, 1927. 2 females.

Station 115, south-west of Inuboe-zaki, 18 m. deep. March 3, 1927. 3 males.

Station 118, between Siwoya-zaki and Inuboe-zaki, 124 m. deep. March 3, 1927. 7 males and 9 egg-bearing females.

Station 121, south-east of Siwoya-zaki, 102 m. deep. March 4, 1927. 2 males.

Station 124, north-east of Siwoya-zaki, 132 m. deep. March 6, 1927. 1 male.

Station 130, north-east of Siwoya-zaki, 82 m. deep. March 11, 1927. 1 male.

Station 131, south of Siwoya-zaki, 99 m. deep. March 12, 1927. 3 males and 6 females.

Station 139–140, east of Kinkazan, 320–344 m. deep. November 24, 1925. 5 males and 8 females.

Station 143, east of Siwoya-zaki, 132 m. deep. November 30, 1925. 1 female.

Station 146, east of Siwoya-zaki, 201 m. deep. November 30, 1925. 8 males and 6 females.

Station 148, south of Kinkazan, 270 m. deep. August 3, 1925. 1 male and 4 females.

Station 161, near Siwoya-zaki, 76 m. deep. November 16, 1926. 3 males.

Station 165, north-east of Siwoya-zaki, 106 m. deep. November 27, 1926. 1 female.

Station 194, near Lake Hamana, 192 m. deep. July 4, 1927. 1 male.

Station 197, east of Toba, Mie-ken, 148 m. deep. July 4, 1927. 1 male.

Station 198, south-east of Toba, Mie-ken, 168 m. deep. July 4, 1927. 1 male.

Station 199, south of Toba, Mie-ken, 207 m. deep. July 11, 1927. 2 males and 2 females, 1 bears eggs.

Station 208, near Siwo-misaki, 219 m. deep. July 13, 1927. 1 male.

Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 male and 1 female.

Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 1 egg-bearing female.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 2 females, 1 bears eggs.

Station 214, Kii Strait, 166 m. deep. July 18, 1927. 1 male.

Station 239, south of Misaki, Kanagawa-ken, 307 m. deep. November 6, 1927. 3 males and 5 females, 4 bear eggs.

Station 244, Sagami Bay, 135 m. deep. November 8, 1927. 2 males and 1 female.

Station 255, north-east of Simoda, 263 m. deep. November 10, 1927. 1 male.

Station 271, west of Suno-saki, 82 m. deep. November 18, 1927. 1 female.

Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 male.

Station 276, near Omae-zaki, 77 m. deep. July 2, 1928. 2 males and 1 female.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male and 1 egg-bearing female.

Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 1 egg-bearing female.

Station 279, Suruga Bay, 155 m. deep. July 2, 1928. 1 male.

Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 2 females.

Station 283, between Omae-zaki and Irô-zaki, 177 m. deep. July 4, 1928. 2 males and 2 females, 1 bears eggs.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 2 males.

Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 3 males and 3 females.

Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 egg-bearing female.

Station 305, off southern Miyazaki-ken, 137 m. deep. July 12, 1928. 1 egg-bearing female.

Station 308, off southern Miyazaki-ken, 155 m. deep. July 14, 1928. 1 egg-bearing female.

Station 310, Bungo Strait, 190 m. deep. July 14, 1928. 1 female.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 8 males and 9 females, 6 bear eggs.

Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 5 males and 1 female.

Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 16 males and 11 females, 5 bear eggs.

Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 male.

Station 362, near Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 female.

Station 369, south of Hamana Lake, 247 m. deep. August

10, 1928. 1 male.

Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 egg-bearing female.

Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1929. 6 males and 5 egg-bearing females.

Station 431, south-east of Gotô Isls., 152 m. deep, July 16, 1929. 2 females, 1 bears eggs.

Station 483, north-west of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 male.

Station 493, off Hamada, Simane-ken, 124 m. deep. August 11, 1929. 1 male.

Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 male and 1 female.

Station 553, north of Mikuni, Hukui-ken, 113 m. deep. July 21, 1930. 1 male and 1 female.

DISTRIBUTION: Japan: Sagami Bay, Uraga Canal, Maizuru, Mutu Bay and above localities.

216. *Pugettia nipponensis* RATHBUN.

RATHBUN, 1932, p. 31.

LOC. Station 188, south-east of Omae-zaki, 214 m. deep. June 30, 1927. 2 egg-bearing females.

Station 200, south of Toba, Mie-ken, 355 m. deep. July 11, 1927. 1 male and 1 female.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 1 egg-bearing female.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 2 males and 3 females, 2 bear eggs.

Station 247, Kii Strait, 128–159 m. deep. November 8, 1927. 1 male.

Station 248, Sagami Bay, 170 m. deep. November 8, 1927. 3 females, 1 bears eggs.

Station 250, Sagami Bay, 604 m. deep. November 9, 1927. 1 male.

Station 251, Sagami Bay, 165 m. deep. November 9, 1927. 3 males.

DISTRIBUTION: Japan: near Doumiki Saki? and above localities.

Depth: 128–604 m.

217. *Pugettia kagoshimensis* RATHBUN.

RATHBUN, 1932, p. 31.

LOC. Station 244, Sagami Bay, 135 m. deep. November 7, 1927. 1 male and 1 female.

In the female specimen, the hepatic spine is obtuse.

DISTRIBUTION: Japan: north-east of Sata-misaki, Kagosima-ken, and above locality.

218. *Pugettia veltima* MIERS.

MIERS, 1886, p. 41, Pl. 6, Fig. 2.

LOC. Station 179, south of Omae-zaki, 187 m. deep. June 28, 1927. 1 egg-bearing female.

Rostrum somewhat shorter than that of the type specimen, and tubercles on the dorsal surface of the carapace seem to be somewhat weak.

DISTRIBUTION: Ki Islands; from Japanese waters it has not been known.

219. *Pugettia elongata* n. sp.

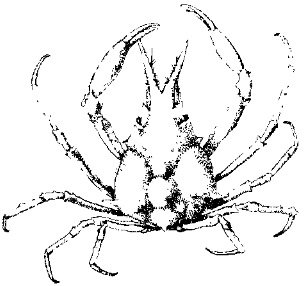
(Text-fig. 54.)

LOC. Station 284, east of Omae-zaki, 71 m. deep. July 4, 1928. 1 male.

Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 1 male.

Carapace elongated pyriform; length a little shorter than two and a half times the length of the rostral horns, and longer than the distance between the extremities of the epibranchial teeth. Rostral horns subcylindric. Supraorbital eave rather narrow, producing to an acute supraorbital tooth. Hepatic expansion not very wide; hepatic projection more acute than postocular tooth. Surface nearly naked, but some setae are distributed somewhere; distinctly areolated. Regions more or less convex. In the medial line, there are three tubercular prominences, a gastric, a cardiac and an intestinal; the last is the most proinemnt.

Inner antenna longitudinal; outer antenna noticeable on either side of rostrum in the dorsal view; basal article broad and flattened on the ventral surface; succeeding two articles rather long and compressed. Merus of external maxilliped subquadrate, dilated antero-external angle and the palp incerted at the anterointernal angle. Cheliped in male well developed; merus with a prominent irregularly dentated carina on the upper margin and one more acute carina on the outer side. Legs slender, tubercular, but shorter than cheliped.



Text-fig. 54. *Pugettia elongata* n. sp. (×2)

Abdomen in male consists of seven segments.

Dimension of the male from Station 284:

Length of carapace without rostral horn	14.0 mm.
Length of rostral horn	5.8
Distance between the extremities of the epibranchial teeth	12.2

Subfamily Microrhynchinae MIERS.

Genus DOCLEA LEACH.

220. *Doclea bidentata* (A. MILNE-EDWARDS).

Libinia bidentata, A. MILNE-EDWARDS, 1873, p. 253.
Doclea orientalis, MIERS, 1879, p. 28, Pl. 2, Fig. 1.
Doclea bidentata, ORTMANN, 1893, p. 48; YOKOYA, 1928, p. 769.

LOC. Station 112, south of Inuboe-zaki, 37 m. deep. March 2, 1927. 2 males.
Station 128, between Kinkazan and Siwoya-zaki, 48 m. deep. March 10, 1927. 2 females.
Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 1 egg-bearing female.

DISTRIBUTION: Mouth of the Amur River; Castri Bay; Vladivostock; Northern Japan: Kunasiri Isl., the east coast of Hokkaidô,

Mutu Bay and above localities. Station 112 is the southern limit of known localities.

Family **Majidae** MIERS.

Subfamily Majinae MIERS.

Genus SCYRA DANA.

221. Scyra compressipes STIMPSON.

STIMPSON, 1857, p. 218; 1907, p. 17, Pl. 3, Fig. 4; MIERS, 1886, p. 63, Pl. 7, Fig. 4; YOKOYA, 1928, p. 770.

LOC. Station 59, north-east of Todo-saki, 168 m. deep. July 19, 1926. 1 male.

Station 76, south of Siriya-zaki, 128 m. deep. July 27, 1926. 2 males and 1 female.

Station 79, near Siriya-zaki, 102 m. deep. November 1, 1926. 1 male.

Station 80, south of Siriya-zaki, 113 m. deep. November 1, 1926. 1 female.

Station 84, south of Siriya-zaki, 101 m. deep. November 2, 1926. 2 females.

Station 90, near Todo-saki, 152 m. deep. November 3, 1926. 4 males and 1 egg-bearing female.

Station 132, about in the middle of Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 2 females.

Station 165, about in the middle of Kinkazan and Siwoya-zaki, 106 m. deep. November 21, 1926. 1 male.

Station 632, north of Oga, 71 m. deep. August 17, 1930. 1 egg-bearing female.

Station 638, west of Tubaki-zaki, Aomori-ken, 73 m. deep. August 18, 1930. 4 males.

Station 645, west of Lake Zyûsan-gata, Aomori-ken, 115 m. deep. August 22, 1930. 1 male.

Station 646, west of Ryûhi-zaki, Aomori-ken, 123 m. deep. August 22, 1930. 1 male.

Station 651, near Ryûhi-zaki, 91 m. deep. August 23, 1930. 8 males and 4 females.

Station 652, Tugaru Strait, 110 m. deep. August 24, 1930. 6 males and 6 females, 5 bear eggs.

Station 655, Tugaru Strait, 112 m. deep. August 30, 1930. 3 males and 3 females, 1 bears eggs.

Station 658, Tugaru Strait, 113 m. deep. August 30, 1930. 4 males and 7 females, 4 bear eggs.

DISTRIBUTION: Northern Japan: Mutu Bay and above localities. Stations 132 and 632 are southern limits on the sides of Pacific and Japan Sea respectively. Depth: to 168 m. PARISI reported from Tokyo Bay and Sagami Bay.

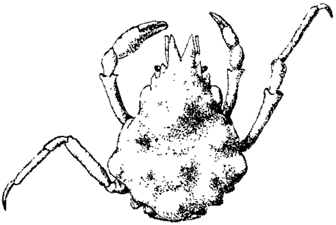
222. Scyra tuberculata n. sp.

(Text-fig. 55.)

LOC. Station 418, south of Satuma, Kagosima-ken, 133 m. deep. July 14, 1929. 1 male.

Station 425, near Kosiki Isls., 300 m. deep. July 15, 1929. 1 female.

Near preceding species. Carapace tuberculated; rostral horns depressed. Orbit rather small, with a wide hiatus above and below. Supraorbital eave producing to a point. On the middle line of the carapace, there are three tubercles, a gastric, a cardiac and an intestinal; one more small tubercle on each side of the gastric one a little before the level of this. Besides two branchial tubercles an outer round one forms the broadest point of the carapace. On the posterolateral margin of the carapace there is a small tubercle. Basal antennal article moderate in width, without spine or tubercle, the two following articles cylindrical and not concealed by rostrum. Merus of maxilliped distally truncated, notched at antero-internal angle. A prominent ridge above the base of cheliped. Legs subcylindrical and moderate in length. Abdomen divided into seven segments.



Text-fig. 55. *Scyra tuberculata* n. sp. (×2)

Dimensions:

	female	male
Length of carapace including rostrum	19.1 mm.	11.2 mm.
Length of carapace excluding rostral horns	17.2	9.5
Width of carapace at broadest point	14.3	8.2
Width of carapace at the base of rostrum	2.7	2.6

Genus **MAJA** LAMARCK.

223. Maja miersii WALKER.

WALKER, 1890, p. 113, Pl. 6, Figs. 1–3; PARISI, 1915, p. 289.

LOC. Station 453, between Saisyûtô Isl. and Gotô Isls., 148 m. deep. July 23, 1929. 1 female.
Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 1 male.

DISTRIBUTION: Singapore; Japan: Sagami Bay and above localities.

224. Maja japonica n. sp.

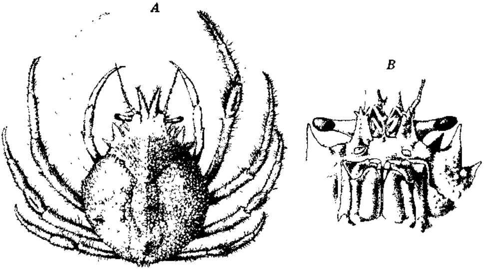
(Text-fig. 56.)

LOC. Station 198, east of Toba, Mie-ken, 168 m. deep. July 4, 1927. 1 male.
Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 2 males.
Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 1 female.
Station 293, east of Tanegasima Isl., 203 m. deep. July 10, 1928. 1 male and 1 female.
Station 301, east of Ariake Bay, Kagosima-ken, 181 m. deep. July 12, 1928. 1 egg-bearing female.
Station 322, west of Muroto-zaki, 110 m. deep. July 16, 1928. 1 female.
Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 male.
Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 1 male and 1 female.

Near preceding species, but it differs in the following points:

On the medial line, there are three tubercles, one on each of the gastric, the cardiac and the intestinal regions. These as well as the branchial one are not so strong as those of *M. miersii.* The rostral

horns are shorter than one-sixth the length of carapace. Two spines on the extremity of the basal joint of the outer antenna. The lower



Text-fig. 56. *Maja japonica* n. sp.
A, Entire animal (×1.5) *B*, Antennal and buccal region (×3).

orbital margin is not so distinctly tuberculated, and the preorbital lobe is not so prominent as that of *M. miersii*. The marginal tubercles on the branchial region are very short.

Dimension of a female from Station 322:

Length of carapace in medial line, excluding rostrum	20.8 mm.
Width of carapace at the broadest point	17.7

Genus EURYNOME LEACH.

225. *Eurynome reini* BALSS.

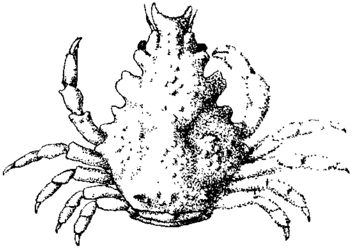
(Text-fig. 57.)

BALSS, 1924, p. 31, Pl. 1, Fig. 3.

LOC. Station 553, north of Mikuni, Hukui-ken, 113 m. deep. July 21, 1929. 1 female.

Body densely covered with short tufty hairs so that scarcely noticeable grooves on the carapace. Rostral horns divergent, middle emargination shallow and U-shaped. Postorbital hood terminally rounded and deeply emarginated between the next broad hepatic lobe; succeeding three marginal teeth terminally rounded. Gastric, cardiac and branchial region convex and nodose, bordered by rather broad

deep furrows. Intestinal region rather broad, with a rather strong spinular tooth on each side and granular between these teeth.



Text-fig. 57. *Eurynome reini* BALSS (×5).

DISTRIBUTION: Japan: Misaki, Sagami Bay and above locality. Depth: 113–180 m.

Genus CHLORINOIDES HASWELL.

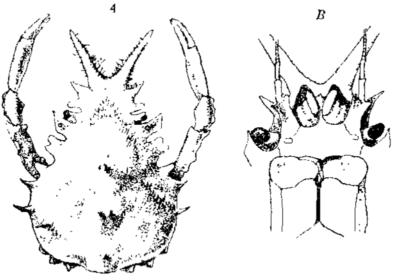
226. Chlorinoides brevispinosa n. sp.

(Text-fig. 58.)

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 1 female.
Station 296, east of Tanegasima Isl., 219 m. deep. July 11, 1928. 1 female.

Carapace granular especially on posterior half; rostral horns straight, strongly divergent, angle between two more than 60°. Preorbital hood divided into two lobes, the anterior one distally pointed and directed outwards and a little forwards; the posterior lobe distally rounded. The supraorbital lobe triangular and distally pointed. The postorbital tooth large, pointed and dorsally flattened. The succeeding two lobes terminally rounded; the anterior broad, the distal margin provided with a ratter deep notch. Two pointed teeth follow the above lobe on the margin. One more pointed tooth on the branchial region, but on the right side no one is found in the specimen from Station 211. Gastric, cardiac and intestinal regions elevated, and each provided with a pointed but rather short tooth;

tooth on cardiac region with paired tips. Posterior margin rounded and with no tooth provided.



Text-fig. 58. *Chlorinoides brevispinosa* n. sp.
A, Entire animal (×3). *B*, Antennal buccal region (×5).

Chelipeds subequal; merus three carinated, each carina provided with flattened teeth; carpus also carinated on the outer margin. chela smoothly surfaced, palm longer than finger.

Abdomen of female broad, consists of seven segments, broadest at antepenultimate segment.

The species near *C. goldsboroughi* RATHBUN[1], differs from this in presence of only one gastric tooth and the postocular tooth is anterolaterally pointed.

Genus PARAMITHRAX MILNE-EDWARDS.

Subgenus Leptomithrax MIERS.

227. *Paramithrax* (*Leptomithrax*) *edwardsi* DE HAAN.

Maja (*Paramithrax*) *edwardsi*, DE HAAN, 1835, p. 92, Pl. 21, Fig. 2.
Paramithrax (*Leptomithrax*) *edwardsi*, ORTMANN, 1893, p. 52; RATHBUN, 1893, p. 81; DOFLEIN, 1902, p. 656; PARISI, 1915, p. 289.

LOC. Station 276, near Omae-zaki, 77 m. deep. July 2, 1928. 1 female.

Station 401, east of Owase, Mie-ken, 303 m. deep. March

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1) RATHBUN, 1906, p. 881, Pl. 14, Fig. 7.

3, 1928. 1 male.

Station 410, west of Kagosima-ken, 139 m. deep. April 25, 1928. 1 male.

Station 411, west of Kagosima-ken, 121 m. deep. April 25, 1928. 1 male.

Station 450, west of Gotô Isls., 205 m. deep. July 22, 1929. 1 female.

Station No. missing, Tusima Strait, July 24, 1929. 1 male and 1 egg-bearing female.

Station 471, north-west of Nagato, Yamaguti-ken, 90 m. July 27, 1929. 1 egg-bearing female.

DISTRIBUTION: Japan: Sagami Bay, off Hukui-ken, off Niigata-ken and above localities.

228. *Paramithrax (Leptomithrax) bifidus* ORTMANN.

ORTMANN, 1893, p. 52, Pl. 3, Fig. 6; PARISI, 1915, p. 290, Pl. 7, Fig. 2.

LOC. Station 240, Sagami Bay, 192 m. deep. November 6, 1927. 1 male.

Station 271, west of Suno-saki, 82 m. deep. November 18, 1927. 1 male.

Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 2 males.

Station 287, near Omae-zaki, 73 m. deep. July 4, 1928. 1 male.

Station 330, near Asizuri-zaki, 102 m. deep. July 22, 1928. 1 male.

Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 2 females, 1 bears eggs.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 female.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male and 1 female.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 male and 2 females, 1 bears eggs.

Station 466, north-west of Iki Isl., 110 m. deep. July 25, 1929. 1 male and 1 egg-bearing female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Kii Strait and above localities.

Genus NAXIA MILNE-EDWARDS.

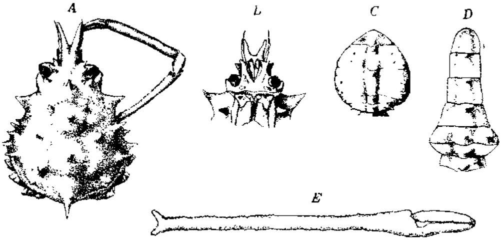
229. *Naxia hystrix* MIERS.

(Text-fig. 59.)

MIERS, 1886, p. 60, Pl. 6, Fig. 4; POCOCK, 1890, p. 79; ALCOCK, 1896, p. 220; PARISI, 1915, p. 293; BALSS, 1924, p. 32; SAKAI, 1932, p. 46, Text-fig. 4, Pl. 3. Fig. 1.

LOC. Station 275, Suruga Bay, 62 m. deep. July 2, 1928. 1 male.
Station 324, Bungo Strait, 106 m. deep. July 21, 1928. 1 female.
Station 470, between Iki Isl. and Simonoseki, 73 m. deep. July 25, 1929. 1 egg-bearing female.
Station 484, northern coast of Nagato, Yamaguti-ken, 73 m. deep. July 25, 1929. 2 males and 2 egg-bearing females.
Station 485, north-east of Nagato, Yamaguti-ken, 93 m. deep. August 11, 1929. 1 male.
Station No. missing, Tusima Strait, July 24, 1929. 1 male.

In the specimens, the rostral horns seem to be somewhat longer than those of the previous authors.



Text-fig. 59. *Naxia hystrix* MIERS.
A, Entire animal of a female (×2). *B*, Antennal, buccal region (×2). *C*, Abdomen of female. *D*, Abdomen of male (×2). *E*, Right chela of male (×1).

Dimension:

	Larger male from Stat. 484	Female from Stat. 470
Length of carapace (from tip of rostral horn to distal end of intestinal tooth)	28.0 mm.	18.9 mm.

Width of carapace (distance between distal ends of epibranchial teeth)		24.9 mm.	13.2 mm.
Cheliped:	Length of merus	57.8	10.1
	Length of carpus	6.3	2.1
	Length of palm	52.9	8.2
	Length of finger	11.4	3.7

DISTRIBUTION: Amboina; Andaman Sea; Japan: Sagami Bay, Suruga Bay, west of Kyûsyû and above localities.

Genus HERBSTIA MILNE-EDWARDS.

No species of this genus has hitherto been known from Japanese waters.

230. Herbstia japonica n. sp.

(Text-fig. 60.)

LOC. Station 110, south of Inuboe-zaki, 59 m. deep. March 2, 1927. 2 males.

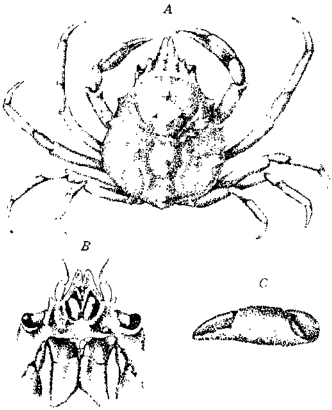
Station 125, between Kinkazan and Siwoya-zaki, 44 m. deep. March 6, 1927. 1 male.

Specimens before me are rather small in size; in the largest, the carapace is 10.9 mm. long and 8.0 mm. broad.

Carapace pear shaped; surface minutely granular and provided with downy hairs, especially many on legs. Rostrum of moderate length consists of two horns, which are closely in contact with each other and the distal end is emarginated. Supraorbital lobe produces to a point. Behind the postocular tooth there are four small tubercles on the lateral margin of the carapace, in these tubercles the anterior one or two are more prominent than the remaining and terminally pointed. Carapace distinctly areolated; on the gastric region there are four small tubercles, two are medial and the remaining two are a little in front of the posterior median tubercle, one on each side. Some small tubercles on the branchial region are along the lateral margin, while the others are on the boundary between the gastric region.

Orbit shallow, eye-stalk of moderate length is not entirely contracted in it. Inner antenna almost longitudinal. In the outer antenna the basal joint is rather broad and its ventral surface is a little longitudinally furrowed; the following two joints are compressed and the flagellum slender. The epistom is moderately long, and the

pterygostomian region is bordered by a rather deep groove from the subhepatic region. The external maxillipeds cover the buccal area, which is subquadrate in shape. In the said external maxilliped, the exognath is broad in the midway; the merus of the endognath dilating at the distal outer corner bears the palp at the distal inner corner. Chelipeds in male subequal; merus subcylindrical and two-thirds as long as the palm, the latter is somewhat laterally compressed, but not carinated. The succeeding legs are similar in feature; the anterior is the longest and successively diminished in length to the posterior. The dactyli are provided with downy hairs on the proximal half, while the distal halves are naked and terminally sharply pointed.



Text-fig. 60. *Herbstia japonica* n. sp. *A*, Entire animal (×5). *B*, Antennal, buccal region (×8). *C*, Left chela (×8).

The abdomen of the male consists of seven segments.

Genus CHORILIA DANA.

231. Chorilia longipes japonica MIERS.

Hyastenus (Chorilia) japonica, MIERS, 1879, p. 27, Pl. 1, Fig. 2.
Chorilia longipes, DANA, 1852, p. 91; atlas, 1855, Pl. 1, Fig. 5.
Hyastenus (Chorilia) longipes, MIERS 1879, p. 658.
Hyastenus longipes, MIERS, 1886 p. 56; RATHBUN, 1893, p. 85, Pl. 7; 1894, p. 62, Pl. 1, Fig. 5.
Halimus japonicus, PARISI, 1915, p. 291.

LOC. Station 26, north-east of Siwoya-zaki, 232 m. deep. July 23, 1926. 3 males and 2 females.

Station 45, between Todo-saki and Kinkazan, 349 m. deep. July 9, 1926. 5 males and 9 females.

Station 58, north-east of Todo-saki, 177 m. deep. July 18, 1926. 5 males and 7 egg-bearing females.

Station 59, north-east of Todo-saki, 168 m. deep. July 19, 1926. 3 egg-bearing females.

Station 61, north of Todo-saki, 170 m. deep. July 21, 1926. 3 males and 2 females.

Station 66, between Siriya-zaki and Todo-saki, 165 m. deep. July 21, 1926. 5 males and 4 females, 2 bear eggs.

Station 68, between Siriya-zaki and Todo-saki, 179 m. deep. July 25, 1926. 7 males and 4 females, 2 bear eggs.

Station 70, south-east of Siriya-zaki, 285 m. deep. July 26, 1926. 4 males and 3 females, 1 bears eggs.

Station 74, south of Siriya-zaki, 219 m. deep. July 27, 1926. 2 males and 1 female.

Station 122, east of Siwoya-zaki, 161 m. deep. March 6, 1927. 5 males and 3 females, 1 bears eggs.

Station 125, between Kinkazan and Siwoya-zaki, 44 m. deep. March 6, 1927. 1 female.

Station 136–137, east of Kinkazan, 194–238 m. deep. March 12, 1925. 1 female.

Station 143, east of Siwoya-zaki, 132 m. deep. November 30, 1925. 2 males and 8 females, 1 bears eggs.

Station 146, east of Siwoya-zaki, 201 m. deep. November 30, 1925. 7 males and 9 females.

DISTRIBUTION: East Sea of Japan: Sagami Bay and above localities.

Genus CHIONECETES KRÖYER.

232. *Chionecetes opilio* (O. FABRICIUS).

Cancer phalangium, O. FABRICIUS, 1780, p. 234.

Cancer opilio, O. FABRICIUS, 1788, p. 182.

Chionecetes opilio, KRÖYER, 1838, p. 249; RATHBUN, 1925, p. 233, Pls. 84, 85.

Chionecetes opilio elongatus, RATHBUN, 1924, p. 3.

LOC. Station 37, east of Kinkazan, 214 m. deep. July 3, 1926. 1 young female.
Station 169, north-east of Kinkazan, depth unrecorded. November 29, 1926. 1 female.
Station 480, north-east of Tusima Isl., 280 m. deep. August 8, 1929. 1 male.
Station 487, north of Misima Isl., 194 m. deep. August 11, 1929. 1 female.
Station 577, north-east of Noto, 311 m. deep. July 28, 1930. 1 egg-bearing female.

In the specimen from Station 169, the carapace is wider than long, but in other respects it differs from *Chionecetes bairdi* RATHBUN (RATHBUN, 1924, p. 3; 1925, p. 235, Pls. 86, 87).

DISTRIBUTION: West of Greenland; Arctic Alaska; Bering Sea; East of Siberia; Okhotsk Sea; Sakhalin Island; East of Korea; Japan: off Kinkazan on the Pacific side, on the side of Japan Sea: from south-westwards to Oki Isls. and above localities.

Family **Parthenopidae** MIERS.

Subfamily Parthenopinae MIERS.

Genus **LAMBRUS** LEACH.

233. *Lambrus (Parthenopoides) pteromerus* ORTMANN.

ORTMANN, 1893, p. 416, Pl. 17, Fig. 1; BALSS, 1922, p. 135.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 2 males.
Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 3 males and 1 female.
Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 2 females, 1 bears eggs.
Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 1 male.
Station 329, west of Asizuri-zaki, 296 m. deep. July 22, 1928. 1 female.
Station 353, near Tanabe, Wakayama-ken, 192 m. deep. August 4, 1928. 1 female.
Station 438, south-west of Gotô Isls., 219 m. deep. July

19, 1929. 1 male.

Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 1 male.

Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 1 male.

Station 451, west of Gotô Isls., 187 m. deep. July 22, 1929. 3 females, 1 bears eggs.

Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 5 males and 2 females, 1 bears eggs.

Station 575, north of Noto, 123 m. deep. July 28, 1930. 1 male.

Station 580, Toyama Bay, 135 m. deep. July 29, 1930. 3 males.

Station 618, off the mouth of the Mogami River, 135 m. deep. August 14, 1930. 1 female.

Station 647, west of Lake Zyûsan-gata, 86 m. deep. August 23, 1930. 1 female.

DISTRIBUTION: Japan: Sagami Bay and above localities.

SUBTRIBE BRACHYRHYNCHEA.

Family **Cancridae** ALCOCK.

Subfamily Cancrinae ALCOCK.

Genus **CANCER** LINNAEUS.

234. Cancer gibbosulus (DE HAAN).

Corystes (Trichocera) gibbosulus, DE HAAN, 1835, p. 45, Pl. 2, Fig. 4, Pl. 13, Fig. 3.
Cancer gibbosulus, RATHBUN, 1898, p. 581; SCHMITT, 1921, p. 226, Pl. 36, Fig. 7; BALSS, 1922, p. 94.
Trichocera gibbosula, STIMPSON, 1907, p. 87.
Trichocarcinus affinis, MIERS, 1879, p. 35.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 1 male and 1 female.

Station 46, south of Todo-saki, 165 m. deep. July 9, 1926. 1 female.

Station 79, near Siriya-zaki, 102 m. deep. November 1, 1926. 1 male and 1 female.

Station 81, south of Siriya-zaki, 172 m. deep. November

1, 1926. 2 males.

Station 89, north of Todo-saki, 124 m. deep. November 3, 1926. 1 male.

Station 90, near Todo-saki, 152 m. deep. November 6, 1926. 1 female.

Station 95, between Todo-saki and Kinkazan, 141 m. deep. November 7, 1926. 1 female.

Station 125, between Kinkazan and Siwoya-zaki, 44 m. deep. March 6, 1927. 3 males and 1 female.

Station 126, between Kinkazan and Siwoya-zaki, 146 m. deep. March 7, 1927. 2 males and 1 egg-bearing female.

Station 132, between Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 1 male.

Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 1 male.

Station 146, east of Siwoya-zaki, 201 m. deep. November 30, 1925. 2 males.

Station 148, south of Kinkazan, 270 m. deep. August 3, 1925. 1 male.

Station 195, south of Lake Hamana, 172 m. deep. July 2, 1927. 1 male.

Station 198, south-east of Toba, Mie-ken, 168 m. deep. July 4, 1927. 1 male and 1 female.

Station 199, south of Toba, Mie-ken, 207 m. deep. July 11, 1927. 1 female.

Station 239, south of Misaki, Kanagawa-ken, 307 m. deep. November 6, 1927. 1 female.

Station 251, Sagami Bay, 165 m. deep. November 9, 1927. 1 female.

Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 2 males and 3 females.

Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 1 female.

Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 1 male.

Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 male.

Station 449, north of Gotô Isls., 155 m. deep. July 22,

1929. 1 male.

Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 1 female.

Station 459, west of Tusima Isl., 115 m. deep. July 23, 1929. 1 female.

Station 465, north of Gotô Isls., west of Hirato, 106 m. deep. July 24, 1929. 1 female.

Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 2 males.

Station 471, west of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 female.

Station 658, north of Siriya-zaki, 113 m. deep. August 30, 1930. 4 males and 4 females.

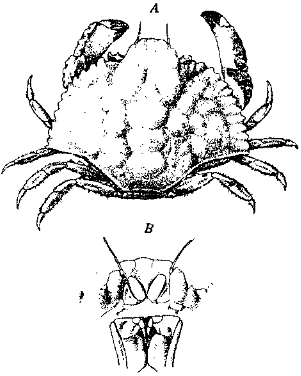
DISTRIBUTION: Japan: Nagasaki, Korea Strait, Northern Japan .nd above localities; on the eastern Pacific coast: from Granite Cove, 'ort Althorp, Alaska to San Gernimo Island, California. It has iitherto been known from shallow water to 40 fathoms.

235. *Cancer tumifrons* n. sp.

(Text-fig. 61.)

LOC. Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

The species is easily dis-inguishable from other species f this genus in the form of he front of the carapace. The 'ront consists of five lobes as vell as other species of the ;enus, but these are flat and he inner three lobes being losely in contact with each ther, project considerably nore forwards than the outer obes, and are nearly equal in ength. The eye-stalk is pro-



Text-fig. 61. *Cancer tumifrons* n. sp. *A*, Entire animal (×2). *B*, Antennal, buccal region (×3).

vided with two rather prominent tubercles on the anterior margin.

Dimension:

Length of carapace	14.7 mm.
Width of carapace	19.8

Another specimen, I examined from Misaki, Kanagawa-ken, is a little larger than this.

Subfamily Thiinae ALCOCK.

Genus **KRAUSSIA** DANA.

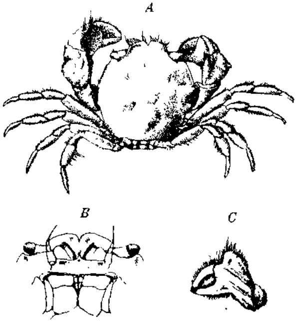
236. Kraussia laevis n. sp.

(Text-fig. 62.)

LOC. Station 520, north of Mihonoseki, Simane-ken, 75 m. deep. August 23, 1929. 1 male.

The species differs in a flattened and smooth carapace from other species of the genus.

Carapace globular, flat; regions pretty well defined. Front horizontal and bilobed. Lateral margin arcuate, with two notches. A few long hairs scuttered on the surface, those on frontal margin especially long and many in number. Inner antenna oblique. Basal article of outer antenna is on the inner hiatus of orbit. Epistom of considerable length. Buccal area quadrate, somewhat broader anteriorly. External maxillipeds cover the area; merus short and somewhat dilated at antero-external angle; palp on antero-internal angle. Chelipeds subequal; chela strongly compressed; palm deep, upper and lower margins fringed with long hairs; its outer surface with two or three longitudinal grooves, which are



Text-fig. 62. *Krausia laevis* n. sp. *A*. Entire animal (×3). *B*. Antennal, buccal region (×6). *C*. Chela of left side (×3).

rather shallow and wide, fringed with short hairs. Fingers also fringed with hairs on upper and lower margins, widely gaping at the base. Posterior four pairs of legs similarly shaped; anterior pair a little longer than posterior, fringed with hairs on both margins and unarmed.

Abdomen in male consists of seven segments; third the widest, the last terminally rounded.

Subfamily Acanthocyclinae ALCOCK.

Genus **ERIMACRUS** BENEDICT.

237. ***Erimacrus isenbecki*** (BRANDT).

Platycorystes (Podocamthus) isenbecki, BRANDT, 1848, p. 179; 1851, p. 83, 147.

Erimacrus isenbecki, BENEDICT 1892, p. 229, Pl. 26, Figs. 5-7, Pl. 27; BALSS, 1922, p. 98.

LOC. Station 135, east of Kinkazan, 159 m. deep. November 21, 1925. 1 male and 1 female.

Station 136, east of Kinkazan, 194 m. deep. November 21, 1925. 1 male.

Station 138, east of Kinkazan, 285 m. deep. November 24, 1925. 1 female.

Station 159, north-east of Inuboe-zaki, 208 m. deep. November 13, 1926. 1 male.

Station 176, south-east of Kinkazan, 123 m. deep. July 25, 1923. 2 males.

Station 530, off Kinosaki, Kyôto-hu, 183 m. deep. August 24, 1929. 1 broken specimen.

Station 558, west of Noto, 188 m. deep. July 22, 1930. 1 female.

Station 613, north-east of Sado Isl., 254 m. deep. August 13, 1930. 1 broken specimen.

Station 654, near Ôma-zaki, Tugaru Strait, 44 m. deep. August 30, 1930. 1 male.

DISTRIBUTION: Bering Sea; Aleutian Islands and Alaska; Kunaziri Isl.; south-east of Hokkaidô; east coast of Korea; Japan: Besides above localities, it is not rare in Niigata-ken, Toyama-ken and Hukui-ken; on the side of Japan Sea, Station 530 is the south-western limit

of the distribution, while on the Pacific side Station 159 is the southern limit.

Genus **TRACHYCARCINUS** FAXON.

238. ***Trachycarcinus balssi*** RATHBUN.

Trachycarcinus corallinus, BALSS, 1922, p. 100, Pl. 2, Fig. 6.
Trachycarcinus balssi, RATHBUN, 1932, p. 36.

LOC. Station 259, Suruga Bay, 188 m. deep. November 15, 1927. 1 male.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 2 males and 1 female.
Station 282, Suruga Bay, 110 m. deep. July 4, 1928. 2 females.
Station 290, east of Omae-zaki, 143 m. deep. July 4, 1928. 1 female.
Station 327, west of Asizuri-zaki, 276 m. deep. July 21, 1928. 1 female.
Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 male.
Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 2 males.
Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 female.
Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 3 males and 1 female.
Station 455, north-east of Saisyûtô Isl., 90 m. deep. July 23, 1929. 1 male and 1 female.
Station 459, west of Tusima Isl., 115 m. deep. July 23, 1929. 1 male and 1 female.
Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 male.
Station 546, Wakasa Bay, 101 m. deep. July 20, 1930. 1 female.
Station 572, north of Noto, 132 m. deep. July 27, 1930. 1 female.
Station 575, north of Noto, 123 m. deep. July 29, 1930. 1 male.
Station 580, Toyama Bay, 135 m. deep. July 29, 1930. 3

males and 4 females.

Station 599, north-west of Sado Isl., 181 m. deep. August 9, 1930. 1 male.

Station 645, west of Lake Zyûsan-gata, 115 m. deep. August 22, 1930. 1 female.

No specimen referable to *Trachycarcinus sagamiensis* RATHBUN (1932, p. 36) is in the collection.

DISTRIBUTION: Cape Rollin, Simushir Island; Golden Hind; Japan: above localities.

Family **Portunidae** DANA.

Subfamily Portuninae ALCOCK.

Genus **PORTUNUS** O. FABRICIUS.

239. Portunus corrugatus strigilis STIMPSON.

Portunus strigilis, STIMPSON, 1858, p. 38; 1907, p. 74, Pl. 9, Fig. 6.
Liocarcinus strigilis, RATHBUN, 1902, p. 25; PARISI, 1916, p. 170.
Portunus corrugatus, DE HAAN, 1835, p. 40; MIERS, 1879, p. 34; ORTMANN, 1893, p. 70.
Portunus corrugatus strigilis, BALSS, 1922, p. 101.

LOC. Station 117, north of Inuboe-zaki, 57 m. deep. March 3, 1927. 1 female.

Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 female.

Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1 male and 1 female.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 female.

Station 459, west of Tusima Isl., 115 m. deep. July 23, 1929. 1 female.

Station 464, between Tusima Isl. and Gotô Isls., 146 m. deep. July 24, 1929. 1 female.

Station 638, west of Tubaki-zaki, Aomori-ken, 73 m. deep. August 18, 1930. 1 male and 9 females.

Station 646, west of Ryûhi-zaki, Aomori-ken, 123 m. deep. August 22, 1930. 1 male and 1 female.

Station 647, south-west of Ryûhi-zaki, 86 m. deep. August 23, 1930. 1 female.

DISTRIBUTION: Japan: Sagami Bay, Wakanoura, Kagosima, Nagasaki, Gotô Isls., Korea Strait and above localities.

Genus **OVALIPES** RATHBUN.

240. Ovalipes trimaculatus (DE HAAN).

Anisopus trimaculata, DE HAAN, 1833, p. 13.
Platyonychus bipustulatus, MILNE-EDWARDS, 1834, p. 437, Pl. 17, Figs. 7-10; ORTMANN, 1893, p. 65.
Ovalipes bipustulatus, RATHBUN, 1898, p. 597.
Ovalipes trimaculatus, DOFLEIN, 1904, p. 92, Pl. 32, Fig. 6; BALSS, 1922, p. 101.

LOC. Station 133, north of Inuboe-zaki, 33 m. deep. March 12, 1927. 3 males and 1 female.

DISTRIBUTION: Indopacific region; in Japan it distributes northwards to Hakodate, Hokkaidô.

241. Ovalipes iridescens (MIERS).

Platyonychus iridescens, MIERS, 1886, p. 202, Pl. 17, Fig. 2.

LOC. Station 318, Bungo Strait, 324 m. deep. July 16, 1928. 1 broken cheliped.
Station 329, west of Asizuri-zaki, 296 m. deep. July 22, 1928. 1 broken specimen.
Station 425, near Kosiki Islands, 300 m. deep. July 15, 1929. 1 male.

DISTRIBUTION: Ki Islands (140 fathoms); from Japanese waters it has not hitherto been known.

Subfamily Lupinae ALCOCK.

Genus **CHARYBDIS** DE HAAN.

242. Charybdis (Gonioneptunus) subornata ORTMANN.

Thalamita truncata, DE HAAN, 1837, p. 65, Pl. 12, Fig. 3 (female), Pl. 18, Fig. 2 (male).
Gonioneptunus subornatus, ORTMANN, 1893, p. 79, Pl. 3, Fig. 9.
Charybdis subornata, RATHBUN, 1902, p. 28; PARISI, 1916, p. 174; BALSS, 1922, p. 103.

LOC. Station 161, near Siwoya-zaki, 76 m. deep. September 16, 1926. 1 male and 2 females, 1 bears eggs.

Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 1 male and 1 female.
Station 347, north-east of Muroto-zaki, 126 m. deep. July 29, 1928. 1 female.
Station 363, east of Owase, Mie-ken, 439 m. deep. August 17, 1930. 1 female.
Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 5 males and 3 females.
Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 7 females, 1 bears eggs.
Station 422, west of Kagosima-ken, 88 m. deep. July 15, 1929. 1 male.
Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1929. 4 females.
Station 454, east of Saisyûtô Isl., 113 m. deep. July 23, 1929. 1 male.
Station 461, west of Tusima Isl., 120 m. deep. July 24, 1929. 1 female.
Station 483, north-west of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 female.
Station 504, near Oki Isls., 106 m. deep. August 18, 1929. 1 male and 3 females.
Station 540, near Kyô-gasaki, 123 m. deep. August 25, 1929. 1 female.
Station 583, Toyama Bay, 110 m. deep. July 30, 1930. 1 male.
Station 594, north-west of Niigata, 72 m. deep. August 4, 1930. 1 egg-bearing female.
Station No. missing, northern Japan Sea, August 1930. 7 males and 4 females.
Station 635, north of Oga, 46 m. deep. August 18, 1930. 1 male and 1 female.

DISTRIBUTION: Japan: Tokyo Bay, Kôti, Kagosima, Nagasaki, Inland Sea, Maizuru and abave localities. Gulf of Martaban. Depth: to 439 m.

243. Charybdis miles DE HAAN.

Portunus (Charybdis) miles, DE HAAN, 1835, p. 41, Pl. 11, Fig. 1.
Charybdis miles, STIMPSON, 1858, p. 39; 1907, p. 82; DOFLEIN, 1902,

p. 659; RATHBUN, 1902, p. 27; PARISI, 1916, p. 175; BALSS, 1922, p. 104.
Goniosoma miles, A. MILNE-EDWARDS, 1861, p. 378; ORTMANN, 1893, p. 81.
Charybdis (Goniosoma) miles, ALCOCK, 1899, p. 62.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 1 young female.
Station 402, east coast of Kagosima-ken, 86 m. deep. April 29, 1928. 1 male.
Uwazima, Ehime-ken, market. December 1, 1928. 1 female.
Station 407, between Kôti and Asizuri-zaki, 100 m. deep. December 7, 1928. 1 male.
Station 411, south of Kosiki Isls., 121 m. deep. April 25, 1929. 1 female.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Inland Sea, Kôti and above localities. Hongkong; Gulf of Martaban. I have examined some specimens from Formosa.

244. *Charybdis variegata* DE HAAN.

Portunus (Charybdis) variegata, DE HAAN, 1835, p. 42, Pl. 1, Fig. 2.
Charybdis variegata, ALCOCK, 1899, p. 60; RATHBUN, 1902, p. 27; STIMPSON, 1907, p. 81, Pl. 9, Fig. 7; BALSS, 1922, p. 104.
Charybdis bimaculata, MIERS, 1886, p. 190, Pl. 15, Fig. 3; ALCOCK, 1899, p. 69.

LOC. Station 128, south of Kinkazan, 48 m. deep. March 7, 1927. 1 male.

DISTRIBUTION: Japan: Tokyo Bay, Inland Sea, Nagasaki and above locality. Northern China Sea; Hongkong; Siam; Indian coast; Gulf of Persia; Red Sea. Above locality is the northern limit of known localities.

245. *Charybdis (Goniohellenus) truncatus* (FABRICIUS).

Thalamita truncata, DE HAAN, 1835, p. 43, Pl. 2, Fig. 3, Pl. 12, Fig. 3 (male).
Goniosoma ornatum, MIERS, 1879, p. 33; HENDERSON, 1893, p. 376; ORTMANN, 1893, p. 83; DE MAN, 1895, p. 562; MIERS, 1886, p. 191.
Charybdis truncata, BORRADAILE, 1902, p. 200; RATHBUN, 1902, p. 27; STIMPSON, 1907, p. 82.
Charybdis (Goniohellenus) truncatus, BALSS, 1922, p. 103.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep.

February 26, 1928. 2 males and 6 females.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Wakanoura, Kôti, Ôsima, Gotô Isls. and Nagasaki. Hongkong; Philippine Islands; Arafura Sea; Siam; Ceylon; Java; Celebes; Singapore; India.

Genus NEPTUNUS DE HAAN.

246. *Neptunus pelagicus* (LINNÉ).

ALCOCK, 1899, p. 35 (other previous literature); PARISI, 1916, p. 171; KEMP, 1915, p. 248; 1918, p. 250; BALSS, 1922, p. 107; DE MAN, 1925, p. 309, Pl. 10, Fig. b, Pl. 11.
Portunus pelagicus, RATHBUN, 1902, p. 26.
Lupa pelagica, STIMPSON, 1907, p. 107.

LOC. Uwazima, Ehime-ken, market, December 1, 1928. 1 female.

DISTRIBUTION: In the whole Indopacific region: from the Red Sea and east coast of Africa to Tahiti and Japan. Japan: besides Nagasaki and above locality. I have some specimens from Misaki and Tanabe, Wakayama-ken. After H. MUNRO FOX this species migrates through the Suez Canal into the Mediterranean since 1889.

247. *Neptunus trituberculatus* MIERS.

MIERS, 1879, p. 221; 1880, p. 338; 1886, p. 172; BALSS, 1922, p. 107; YOKOYA, 1928, p. 772.
Portunus pelagicus, DE HAAN, 1835, p. 37, Pls. 9, 10.
Portunus trituberculatus, RATHBUN, 1902, p. 26; PARISI, 1916, p. 171.
Neptunus pelagicus var. *trituberculatus*, ORTMANN, 1893, p. 74.

LOC. Station No. missing, north-east of Honsyû, July 1926. 1 male.
Station 156, south-west of Inuboe-zaki, 23 m. deep. November 11, 1926. 1 female.
Station 166, south-west of Kinkazan, depth unrecorded. November 21, 1926. 1 female.
Station 168, near Kinkazan, depth unrecorded. November 21, 1926. 1 female.

DISTRIBUTION: China: Tsingtau; Japan: the west coast of Honsyû, Mutu Bay and above loclaities. On the Pacific side, from north of Tokyo Bay it has not hitherto been reported.

248. *Neptunus (Hellenus) hastatoides* (FABRICIUS).

Neptunus hastatoides, ALCOCK, 1899, p. 38 (other literature); BORRADAILE, 1902, p. 208; LANCHESTER, 1900, p. 745, Pl. 45, Fig. 7; BALSS, 1922, p. 108.
Portunus hastatoides, RATHBUN, 1902, p. 27.
Amphitrite hastatoides, STIMPSON, 1907, p. 78.
Lupa hastatoides, DE MAN, 1907, p. 391.

LOC. Station 395, near Tanabe, Wakayama-ken, 46 m. deep. February 26, 1928. 6 males and 6 females.

DISTRIBUTION: Tokyo Bay, Sagami Bay, Inland Sea, Nagasaki and above locality. China: Hankau, Hongkong; Philippine; Malacca; Singapore; Penang; New-Guinea; Ceylon; Andaman; Laccadive; India; Zanzibar.

Genus THALAMITA LATREILLE.

249. *Thalamita prymna* (HERBST).

ALCOCK, 1899, p. 78; CALMAN. 1900, p. 22; PARISI, 1916, p. 176; BALSS, 1922, p. 112.

LOC. Station 294, north of Tanegasima Isl., 102 m. deep. July 10, 1923. 1 young specimen.

DISTRIBUTION: Natal; the Red Sea; India; Malayan Archipelago; Australia; New Caledonia; Tongatabu; Samoa; Loo-Choo Islands; Japan: Tokyo Bay, Sagami Bay, Inland Sea and above locality.

Genus PARATHRANITES MIERS.

250. *Parathranites orientalis* MIERS.

MIERS, 1886, p. 186, Pl. 17, Fig. 1; ALCOCK, 1899, p. 17; RATHBUN, 1911, p. 204.

LOC. Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 2 females.
Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male.
Station 220, west of Muroto-zaki, 234 m. deep. July 19, 1927. 1 male and 3 females.
Station 221, north-west of Muroto-zaki, 209 m. deep. July 20, 1927. 1 female.
Station 222, west of Muroto-zaki, 210 m. deep. July 20,

1927. 1 female.

Station 259, Suruga Bay, 188 m. deep. November 15, 1927. 1 male.

Station 301, east of Kagosima-ken, 181 m. deep. July 12, 1928. 1 male.

Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 male.

Station 412, west of Sata-misaki, Kagosima-ken, 219 m. deep. July 13, 1929. 1 female.

Station 425, near Kosiki Isls., 300 m. deep. July 15, 1929. 2 females.

Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 1 female.

Station 438, south-west of Gotô Isls., 219 m. deep. July 19, 1929. 3 males and 1 female.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 2 females.

Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 3 females.

Station 446, west of Gotô Isls., 117 m. deep. July 20, 1929. 1 male.

Stntion 451, west of Gotô Isls., 187 m. deep. July 22, 1929. 2 males and 3 females.

Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 female.

The specimens strictly coincide with the original description and the figure, but on the dorsal surface of the carapace there are two broad longitudinal bands, which are light brownish in colour, in the alcoholic specimens.

DISTRIBUTION: Ki Islands; north of Admirality Islands; Salomon Bank; from Japanese waters it has not hitherto been known.

Family **Corystidae** ALCOCK.

Genus **PODOCATACTES** ORTMANN.

251. ***Podocatactes hamifer*** ORTMANN.

ORTMANN, 1893, p. 29, Pl. 3, Fig. 1; BALSS, 1922, p. 115.

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22,

1926. 1 female.

Station 16, north of Inuboe-zaki, 530 m. deep. June 24, 1926. 1 male and 3 females.

Station 21, east of Siwoya-zaki, 209 m. deep. June 27, 1926. 3 females.

Station 41, north-east of Kinkazan, 177 m. deep. July 9, 1926. 1 male and 1 female.

Station 46, between Todo-saki and Kinkazan, 165 m. deep. July 9, 1926. 1 male and 2 females.

Station 93, south of Todo-saki, 163 m. deep. November 6, 1926. 1 male and 1 female.

Station 95, between Todo-saki and Kinkazan, 141 m. deep. November 7, 1926. 4 males and 4 females.

Station 96, north of Kinkazan, 102 m. deep. November 7, 1926. 1 male.

Station 97, north of Kinkazan, 123 m. deep. November 7, 1926. 1 male.

Station 98, north of Kinkazan, 106 m. deep. November 7, 1926. 1 female.

Station 99, east of Kinkazan, 148 m. deep. November 8, 1926. 3 males.

Station 103, east of Bôsyû, 117 m. deep. February 26, 1927. 1 male.

Station 105, east coast of Bôsyû, 130 m. deep. February 27, 1927. 1 male.

Station 111, south of Inuboe-zaki, 121 m. deep. March 2, 1927. 1 female.

Station 118, between Siwoya-zaki and Inuboe-zaki, 124 m. deep. March 3, 1927. 1 male.

Station 119, between Siwoya-zaki and Inuboe-zaki, 124 m. deep. March 4, 1927. 3 males and 2 females.

Station 120, south of Siwoya-zaki, 141 m. deep. March 4, 1927. 1 male and 5 females.

Station 121, south of Siwoya-zaki, 102 m. deep. March 4, 1927. 1 male.

Station 122, east of Siwoya-zaki, 161 m. deep. March 6, 1927. 3 males.

Station 123, north-east of Siwoya-zaki, 137 m. deep. March 6, 1927. 1 male.

Station 124, north-east of Siwoya-zaki, 132 m. deep. March 6, 1927. 2 females.

Station 126, between Kinkazan and Siwoya-zaki, 146 m. deep. March 7, 1927. 2 males and 1 female.

Station 131, south of Siwoya-zaki, 99 m. deep. March 14, 1927. 2 males and 1 female.

Station 134, east of Kinkazan, 139 m. deep. November 21, 1925. 2 males.

Station 136, east of Kinkazan, 194 m. deep. November 21, 1925. 2 males.

Station 138, east of Kinkazan, 285 m. deep. November 24, 1925. 1 female.

Station 139–140, east of Kinkazan, 320–344 m. deep. November 24, 1925. 4 males and 4 females.

Station 143, east of Siwoya-zaki, 132 m. deep. November 30, 1925. 4 males and 8 females.

Station 146, east of Siwoya-zaki, 201 m. deep. November 30, 1925. 3 males and 1 female.

Station 176, near Kinkazan, 123 m. deep. July 25, 1923. 1 male.

Station 181, Suruga Bay, 287 m. deep. June 28, 1927. 1 male.

Station 194, coast of Maisaka, Sizuoka-ken, 192 m. deep. July 2, 1927. 2 egg-bearing females.

Station 199, south of Toba, Mie-ken, 207 m. deep. July 11, 1927. 1 male and 1 female.

Station 200, south of Toba, Mie-ken, 355 m. deep. July 11, 1927. 1 male.

Station 205, east of Singû, Wakayama-ken, 224 m. deep. July 12, 1927. 1 female.

Station 223, south of Kôti, 311 m. deep. July 20, 1927. 1 female.

Station 225, south of Kôti, 349 m. deep. July 23, 1927. 1 male.

Station 238, south of Misaki, Kanagawa-ken, 106 m. deep. November 6, 1927. 1 female.

Station 244, Sagami Bay, 135 m. deep. November 7, 1927. 5 males and 2 females.

Station 248, Sagami Bay, 170 m. deep. November 8, 1927.

1 male and 1 female.

Station 251, Sagami Bay, 165 m. deep. November 9, 1927. 1 male and 2 females.

Station 252, Sagami Bay, 389 m. deep. November 9, 1927. 1 male.

Station 281, Suruga Bay, 274–406 m. deep. July 4, 1928. 1 male and 1 female.

Station 360, south of Owase, Mie-ken, 123 m. deep. August 9, 1928. 1 male.

Station 364, east of Owase, Mie-ken, 276 m. deep. August 9, 1928. 1 female.

Station 367, south-east of Toba, Mie-ken, 291 m. deep. August 10, 1928. 1 male.

Station 369, south of Hamana Lake, 247 m. deep. August 10, 1928. 1 female.

Station 435, south of Gotô Isls., 324 m. deep. July 18, 1929. 1 male.

Station 459, west of Tusima Isl., 115 m. deep. July 23, 1929. 1 male.

Station 481, south-east of Tusima Isl., 143 m. deep. August 8, 1929. 4 males and 3 females.

Station 482, north of Misima Isl., 139 m. deep. August 8, 1929. 1 male and 1 female.

Station 486, far north of Nagato, Yamaguti-ken, 139 m. deep. August 11, 1929. 6 males and 3 females.

Station 499, west of Oki Isls., 207 m. deep. August 14, 1929. 1 male and 3 females.

Station 503, near Oki Isls., 146 m. deep. August 18, 1929. 5 males and 1 female.

Station 504, near Oki Isls., 106 m. deep. August 18, 1929. 3 males.

Station 523, off Tottori-ken, 181 m. deep. August 23, 1929. 1 male.

Station 530, off Tottori-ken, 183 m. deep. August 24, 1929. 1 male and 1 female.

Station 540, near Kyô-gasaki, 123 m. deep. August 25, 1929. 5 males and 1 female.

Station 541, near Kyô-gasaki, 150 m. deep. August 25, 1929. 5 males and 10 females.

Station 547, near Wakasa Bay, 172 m. deep. July 20, 1930. 2 males and 1 female.

Station 578, east of Noto, 187 m. deep. July 28, 1930. 2 males and 1 female.

Station 580, Toyama Bay, 135 m. deep. July 28, 1930. 1 female.

Station 582, Toyama Bay, 176 m. deep. July 30, 1930. 1 male.

Station 584, Toyama Bay, 212 m. deep. July 30, 1930. 1 female.

Station 593, west of Niigata, 219 m. deep. August 3, 1930. 1 female.

Station 599, northern coast of Sado Isl., 181 m. deep. August 9, 1930. 1 male.

Station 611, north-east of Sado Isl., 143 m. deep. August 13, 1930. 1 female.

Station 618, off mouth of the River Mogami, 135 m. deep. August 14, 1930. 4 females, 1 bears eggs.

Station 627, south of Oga, 148 m. deep. August 17, 1930. 1 male and 1 egg-bearing female.

Station 628, south-west of Oga, 148 m. deep. August 17, 1930. 1 female.

Station 636, north of Oga, 115 m. deep. August 18, 1930. 1 female.

Station 637, north of Oga, 73 m. deep. August 18, 1930. 1 male.

Station 640, near Tubaki-zaki, 179 m. deep. August 22, 1930. 4 males and 2 females, 1 bears eggs.

Station 643, about in the middle of Lake Zyûsan-gata and Tubaki-zaki, 132 m. deep. August 22, 1930. 2 males.

Station 644, west of Lake Zyûsan-gata, 150 m. deep. August 22, 1930. 2 males and 1 female.

Station 645, west of Lake Zyûsan-gata, 115 m. deep. August 22, 1930. 3 males and 2 females.

Station 653, Tugaru Strait, 108 m. deep. August 24, 1930. 5 males and 1 female.

DISTRIBUTION: Japan: Sagami Bay, entrance of Tokyo Bay and above localities. Depth: 73–406 m.

Genus **GOMEZA** GRAY.

252. Gomeza distincta (DE HAAN).

Corystes distincta, DE HAAN, 1835, p. 45, Pl. 13, Fig. 2.
Gomeza distincta, MAC GILCHRIST, 1905, p. 263; BOUVIER, 1906, p. 482.

LOC. Station 471, north of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 female.

DISTRIBUTION: Japan: Sagami Bay and above locality.

Family **Xanthidae** ORTMANN.

Subfamily Menippinae ORTMANN.

Genus **HETEROPANOPE** STIMPSON.

253. Heteropanope glabra STIMPSON.

STIMPSON, 1858, p. 35; 1907, p. 63, Pl. 8, Fig. 1; PARISI, 1916, p. 186.

LOC. Station 341, south of Kôti, 126 m. deep. July 28, 1928. 1 male.

DISTRIBUTION: Hongkong; Japan: above locality.

Genus **PILUMNUS** LEACH.

254. Pilumnus vespertilio (FABRICIUS).

MILNE-EDWARDS, 1834, p. 418; atlas, 1839, Pl. 14, Fig. 3; MIERS, 1880, p. 234; HASWELL, 1882, p. 65; DE MAN, 1887, p. 295; 1888, p. 58; ORTMANN, 1893, p. 439; STIMPSON, 1907, p. 65; PARISI, 1916, p. 183; BALSS, 1922, p. 117; URITA, 1926, p. 15.

LOC. Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 male.

DISTRIBUTION: Tropic Indo-pacific region: from east of Africa to Hawaii; Loo-choo Isls. Japan: Kagosima and above locality.

255. Pilumnus hirsutus STIMPSON.

STIMPSON, 1858, p. 37; 1907, p. 69, Pl. 9, Fig. 1; MIERS, 1879, p. 31; 1886, p. 54; ORTMANN, 1893, p. 437; BALSS, 1922, p. 117; YOKOYA, 1928, p. 773.

LOC. Station 115, near Inuboe-zaki, 18 m. deep. March 3, 1927. 2 males.

Station 132, between Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 3 males.
Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 2 males.
Station 229, south of Asizuri-zaki, 256 m. deep. July 27, 1927. 1 male and 2 females.
Station 293, west of Tanegasima Isl., 203 m. deep. July 10, 1928. 2 males and 3 females, 1 bears eggs.
Station 294, north of Tanegasima Isl., 102 m. deep. July 10, 1928. 1 female.
Station 296, east of Tanegasima Isl., 219 m. deep. July 11, 1928. 3 males.
Station 325, Bungo Strait, 210 m. deep. July 21, 1928. 1 male.
Station 327, west of Asizuri-zaki, 276 m. deep. July 21, 1928. 1 egg-bearing female.
Station 333, south of Asizuri-zaki, 179 m. deep. July 22, 1928. 1 male.
Station 449, north-west of Gotô Isls., 155 m. deep. July 22, 1929. 2 egg-bearing females.
Station 470, between Mihonoseki and Oki Isls., 37 m. deep. July 25, 1929. 1 male.

DISTRIBUTION: Indo-pacific region to Red Sea; China; Korea; Japan: Tokyo Bay, Sagami Bay, Inland Sea, Mutu Bay and above localities.

256. *Pilumnus major* ORTMANN.

ORTMANN, 1893, p. 439.

LOC. Station 270, Sagami Bay, 91 m. deep. November 18, 1927. 1 male.

DISTRIBUTION: Japan: Tokyo Bay and above locality.

257. *Pilumnus marginatus* STIMPSON.

STIMPSON, 1907, p. 70, Pl. 9, Fig. 2.

LOC. Station 271, south of Misaki, west of Suno-saki, 82 m. deep. November 18, 1927. 1 male and 1 female.

DISTRIBUTION: Loo-Choo Isls.; Japan: above locality.

Genus ACTUMNUS DANA.

258. *Actumnus squamosus* (DE HAAN).

Pilumnus squamosus, DE HAAN, 1835, p. 50; PARISI, 1916, p. 186.
Actumnus squamosus, ORTMANN, 1893, p. 475; BALSS, 1922, p. 119.
Pilumnus lapillimanus, STIMPSON, 1907, p. 68, Pl. 8, Fig. 7.
Pilumnus dehaani, MIERS, 1879, p. 32; 1886, p. 155, Pl. 14, Fig. 1; ORTMANN, 1893, p. 437.

LOC. Station 132, between Siwoya-zaki and Inuboe-zaki, 48 m. deep. March 12, 1927. 1 male.
Station 210, west of Siwo-misaki, 165 m. deep. July 14, 1927. 1 male.
Station 238, south of Misaki, Kanagawa-ken, 106 m. deep. November 6, 1927. 1 male.
Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 male.
Station 289, east of Omae-zaki, 84 m. deep. July 5, 1928. 1 male.
Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 female.
Station 295, north of Tanegasima Isl., 154 m. deep. July 11, 1928. 1 egg-bearing female.
Station 298, of Sata-misaki, Kagosima-ken, 117 m. deep. July 11, 1928. 1 male and 1 female.
Station 300, east of Kagosima-ken, 110 m. deep. July 11, 1928. 2 males and 1 female.
Station 317, coast of Miyazaki-ken, 97 m. deep. July 16, 1928. 1 female.
Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 female.
Station 370, south of Atumi, Aiti-ken, 91 m. deep. August 10, 1928. 1 female.
Station 377, south of Omae-zaki, 82 m. deep. August 14, 1928. 1 female.
Station 420, south of Kosiki Isls., 132 m. deep. July 15, 1929. 3 males and 7 females, 3 bear eggs.
Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1929. 2 females.
Station 431, between Gotô Isls. and Kosiki Isls., 152 m.

deep. July 16, 1929. 1 female.

Station 435, south of Gotô Isls., 324 m. deep. July 18, 1929. 1 female.

Station 439, south-west of Gotô Isls., 155 m. deep. July 19, 1929. 1 male.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 female.

Station 445, near Gotô Isls., 73 m. deep. July 20, 1929. 1 egg-bearing female.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 male and 1 female.

Station No. missing, Tusima Strait, west of Gotô Isls., 60 fms. deep. July 24, 1929. 1 female.

Station 466, west of Iki Isl., 110 m. deep. July 25, 1929. 1 male and 1 female.

Station 467, south-east of Tusima Isl., 110 m. deep. July 25, 1929. 2 males and 1 female.

Station 485, east of Misima Isl., 93 m. deep. August 11, 1929. 2 males and 1 female.

DISTRIBUTION: Ceylon; Singapore; Siam; Beagle Bay; Philippine Islands; China Sea; Japan: Tokyo Bay, Sagami Bay, Nagasaki and above localities.

259. Actumnus setifer (DE HAAN).

Cancer (Pilumnus) setifer, DE HAAN, 1835, p. 50, Pl. 3, Fig. 3.
Actumnus setifer, DE MAN, 1887, p. 262; 1888, p. 47; 1902, p. 639; ORTMANN, 1893, p. 474; BALSS, 1922, p. 119.
Actumnus tomentosus, DANA, 1852, p. 243, Pl. 14, Fig. 2.

LOC. Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1 female.

DISTRIBUTION: In the whole tropic Indo-pacific region: from Zanzibar and Red Sea to Australia, Tahiti and Japan. Japan: Tokyo Bay, Sagami Bay, Kagosima, Nagasaki and above locality.

Subfamily Xanthinae ORTMANN.

Genus ACTAEA DE HAAN.

260. Actaea affinis (DANA).

Actaeodes affinis, DANA, 1852, p. 197, Pl. 11, Fig. 3.

Actaeodes tomentosus, MIERS, 1886, p. 135 (part).
Actaea affinis, RATHBUN, 1906, p. 852.

LOC. Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 1 male and 1 female.

DISTRIBUTION: Hawaii; Polynesian Islands; Queensland; Laccadives; Japan: Ôsima and above locality.

261. *Actaea pilosa* STIMPSON.

STIMPSON, 1858, p. 33; 1907, p. 46, Pl. 5, Fig. 6.

LOC. Station 469, between Simonoseki and Tusima Isl., 91 m. deep. July 25, 1929. 1 male.

DISTRIBUTION: Hongkong; Japan: above locality.

262. *Actaea rufopunctata* (MILNE-EDWARDS).

Xantho rufopunctata, MILNE-EDWARDS, 1834, p. 389.
Actaea rufopunctata, MIERS, 1881, p. 68; 1886, p. 122; ORTMANN, 1893, p. 454; RATHBUN, 1906, p. 852.

LOC. Station 294, north of Tanegasima Isl., 102 m. deep. July 10, 1928. 2 females.

DISTRIBUTION: Dar-es-Salaam; Ceylon; Andamans; Malayan Archipelago; Polynesian Islands; Hawaii; China Sea; Japan: Tokyo Bay and above locality.

263. *Actaea savignyi pura* STIMPSON.

Actaea pura, STIMPSON, 1858, p. 30; 1907, p. 44, Pl. 5, Fig. 7.
Actaea granulata, ORTMANN, 1893, p. 45; ALCOCK, 1898, p. 151; CALMAN, 1900, p. 8.
Actaea savignyi pura, BALSS, 1922, p. 122.

LOC. Station 115, near Inuboe-zaki, 18 m. deep. March 3, 1927. 1 male.

DISTRIBUTION: Australia; Ceylon; coasts of India; Hongkong; China Sea; Japan: Nagasaki, Sagami Bay, Bôsyû and above locality.

264. *Actaea rüppellii* (KRAUSS).

Aegle rüppellii, KRAUSS, 1843, p. 28, Pl. 1, Fig. 1.
Actaea rüppellii, ORTMANN, 1893, p. 454; DE MAN, 1895, p. 499; BALSS, 1922, p. 121.

LOC. Station 115, near Inuboe-zaki, 18 m. deep. March 3, 1927. 2 males and 1 female.

DISTRIBUTION: In western Indo-pacific region: from the east coast of Africa and Red Sea to Queensland. Japan: Nagasaki, Sagami Bay and above locality.

Genus **LOPHOXANTHUS** A. MILNE-EDWARDS.

265. *Lophoxanthus scaberrimus* (WALKER).

Xantho scaberrimus, WALKER, 1887, p. 109-115, Pl. 7, Fig. 1-4; RATHBUN, 1902, p. 25; PARISI, 1916, p. 180.
Lophoxanthus scaberrimus, BALSS, 1922, p. 126.

LOC. Station 406, south of Kôti, 97 m. deep. May 3, 1928. 1 female.

DISTRIBUTION: Singapore; Siam; Hongkong; Japan: Nagasaki, Wakanoura and above locality.

Genus **LEPTODIUS** A. MILNE-EDWARDS.

266. *Leptodius exaratus* (MILNE-EDWARDS).

Chlorodius exaratus, MILNE-EDWARDS, 1834, p. 402; DANA, 1852, p. 208; STIMPSON, 1907, p. 52, Pl. 6, Figs. 3-4, 6-9.
Xantho affinis, DE HAAN, 1835, p. 48, Pl. 13, Fig. 8.
Xantho lividus, DE HAAN, 1835, p. 48, Pl. 13, Fig. 6.
Leptodius exaratus, MIERS, 1879, p. 31; HASWELL, 1882, p. 60; DE MAN, 1888, p. 33; RATHBUN, 1902, p. 25.

LOC. Station 212, west of Tanabe, Wakayama-ken, 181 m. deep. July 14, 1927. 3 males and 2 females.
Station 428, between Nagasaki and Kosiki Isls., 119 m. deep. July 16, 1929. 12 males and 1 female.
Station 471, north-west of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 1 male.

DISTRIBUTION: Indo-pacific region: from the east coast of Africa to Polynesian Islands. Japan: Tokyo Bay, Sagami Bay, east coast of Bôsyû, Inland Sea, Loo-Choo Isls., Nagasaki, Aomori and above localities.

Subfamily Carpiliinae **ORTMANN**.

Genus **XANTHIAS** RATHBUN.

267. Xanthias lamarckii (MILNE-EDWARDS).

Xantho lamarckii, MILNE-EDWARDS, 1834, p. 391; ORTMANN, 1893, p. 448.
Xanthodes lamarckii, DE MAN, 1887, p. 263.
Xanthias lamarckii, RATHBUN, 1906, p. 854.

LOC. Station 352, west of Tanabe, Wakayama-ken, 154 m. deep. August 1, 1928. 1 male.

DISTRIBUTION: Tropic Indo-pacific region. From Japan it has not hitherto been reported.

268. Xanthias tuberculidens RATHBUN.

RATHBUN, 1911, p. 224, Pl. 18, Fig. 9.

LOC. Station 222, west of Muroto-zaki, 210 m. deep. July 20, 1927. 4 females, 2 bear eggs.

Carapace somewhat narrower than that of type specimen; both chelipeds missing.

DISTRIBUTION: Saya de Malha (125 fms.); Japan: above locality.

Genus **CARPILODES** DANA.

269. Carpilodes venosus (MILNE-EDWARDS).

Carpilius venosus, MILNE-EDWARDS, 1834, p. 383.
Xantho obtusus, DE HAAN, 1835, p. 47, Pl. 13, Fig. 5; KRAUSS, 1843, p. 31.
Liomera obtusus, STIMPSON, 1907, p. 38.
Carpilodes venosus, ORTMANN, 1893, p. 468; ALCOCK, 1898, p. 83.

LOC. Station 376, near Omae-zaki, 64 m. deep. August 13, 1928. 1 female.

DISTRIBUTION: Tahiti; Port Molle; New Caledonia; Mauritius; Natal; Pulo Condor; Cochin China; Philippine Islands; Loo-choo; Japan: Tokyo Bay and above locality.

Family **Gonoplacidae** DANA.

Subfamily Pseudorhombilinae ALCOCK.

Genus **CARCINOPLAX** MILNE-EDWARDS.

270. Carcinoplax longimanus (DE HAAN).

Cancer (Curtonotus) longimanus, DE HAAN, 1835, p. 50, Pl. 6, Fig. 1.

Carcinoplax longimanus, ORTMANN, 1894, p. 688; RATHBUN, 1902, p. 23; DOFLEIN, 1902, p. 663; 1904, p. 115, Pl. 36; PARISI, 1918, p. 90.

LOC. Station 594, north-west of Niigata, 72 m. deep. August 4, 1930. 1 male.

DISTRIBUTION: Cape of Good Hope; Andaman Sea; Gulf of Martaban; southern China; Japan: Sagami Bay, Wakanoura, Kagosima, Hakodate and above locality.

Genus PILUMNOPLAX MIERS.

271. Pilumnoplax vestita (DE HAAN).

Cancer (Curtonotus) vestitus, DE HAAN, 1835, p. 51, Pl. 5, Fig. 3.
Pilumnoplax vestita, ORTMANN, 1894, p. 687; BALSS, 1922, p. 136.
Carcinoplax vestitus, PARISI, 1918, p. 91.

LOC. Station 476, west of Iki Isl., 84 m. deep. July 28, 1929. 1 young female.
Station 592, coast of southern Niigata-ken, 68 m. deep. August 3, 1930. 1 male.
Station 534, north-west of Niigata, 72 m. deep. August 4, 1930. 2 females.
Station 624, south of Oga, 73 m. deep. August 15, 1930. 1 male and 1 female.
Station 625, south of Oga, 51 m. deep. August 15, 1930. 1 male.
Station 626, south of Oga, 70 m. deep. August 15, 1930. 2 males.

DISTRIBUTION: Japan: Tokyo Bay, Sagami Bay, Inland Sea, Maizuru and above localities. Depth: 45–110 m.

272. Pilumnoplax americana RATHBUN.

RATHBUN, 1898, p. 283, Pl. 7, Figs. 1, 2; ALCOCK, 1900, p. 311; DOFLEIN, 1904, p. 120, Pl. 35, Figs. 3, 4; PARISI, 1918, p. 91.

LOC. Station 345, near Muroto-zaki, 165–199 m. deep. July 29, 1928. 1 female.
Station 353, near Tanabe, Wakayama-ken, 192 m. deep. August 4, 1928. 1 female.

DISTRIBUTION: Florida; Travancore; Nias; Japan: Sagami Bay and above localities.

273. *Pilumnoplax glaberrima* ORTMANN.

ORTMANN, 1894, p. 687, Pl. 23, Fig. 2.

LOC. Station 179, near Irô-zaki, 187 m. deep. June 28, 1927. 1 male and 1 female.
Station 180, west of Irô-zaki, 276 m. deep. June 28, 1927. 1 female.
Station 188, south-east of Omae-zaki, 214 m. deep. June 30, 1927. 3 males and 1 female.
Station 201, east of Owase, Wakayama-ken, 183 m. deep. July 11, 1927. 1 male.
Station 205, east of Singû, Wakayama-ken, 224 m. deep. July 12, 1927. 1 male.
Station 207, east of Siwo-misaki, 229 m. deep. July 13, 1927. 1 female.
Station 208, near Siwo-misaki, 219 m. deep. July 13, 1927. 1 male.
Station 209, west of Siwo-misaki, 256 m. deep. July 13, 1927. 1 male and 1 female.
Station 211, near Tanabe, Wakayama-ken, 190 m. deep. July 14, 1927. 1 male.
Station 236, north of Suno-saki, 251 m. deep. November 6, 1927. 1 male.
Station 247, Kii Strait, 128–259 m. deep. November 8, 1927. 1 male.
Station 279, Suruga Bay, 155 m. deep. July 2, 1928. 1 female.
Station 304, off southern Miyazaki-ken, 241 m. deep. July 12, 1928. 1 male and 1 female.
Station 341, south of Kôti, 126 m. deep. July 28, 1928. 1 male.
Station 348, Kii Strait, 106 m. deep. July 21, 1928. 1 male.
Station 373, south of Hamana Lake, 128 m. deep. August 13, 1928. 1 female.
Station 431, south-east of Gotô Isls., 152 m. deep. July 16, 1929. 1 female.
Station 435, south of Gotô Isls., 324 m. deep. July 18, 1929. 1 male.
Station 438, south-west of Gotô Isls., 219 m. deep. July

19, 1929. 1 male.

Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

Station 444, south of Gotô Isls., 194 m. deep. July 20, 1929. 2 males and 1 female.

Station 463, south-west of Tusima Isl., 115 m. deep. July 24, 1929. 1 female.

Station 466, west of Iki Isl., 110 m. deep. July 25, 1929. 1 male.

Station 473, north-east of Tusima Isl., 143 m. deep. July 27, 1929. 1 female.

Station 499, west of Oki Isls., 207 m. deep. August 14, 1929. 1 male.

Station 516, east of Oki Isls., 187 m. deep. July 22, 1930. 1 male, 1 female and 2 young speeimens.

Station 542, Wakasa Bay, 119 m. deep. July 18, 1930. 1 male.

Station 546, Wakasa Bay, 101 m. deep. July 20, 1930. 2 males.

Station 549, west of Mikuni, Hukui-ken, 115 m. deep. July 20, 1930. 1 male.

Station 553, north of Mikuni, Hukui-ken, 113 m. deep. July 21, 1930. 1 male and 1 female.

Station 583, Toyama Bay, 110 m. deep. July 30, 1930. 1 male.

Station 587, Toyama Bay, 97 m. deep. August 2, 1930. 1 male, 1 female and 3 youngs.

Station 590, coast of southern Niigata-ken, 112 m. deep. August 3, 1930. 1 male.

Station 592, south-west of Niigata, 68 m. deep. August 3, 1930. 5 males and 3 females.

Station 594, north-west of Niigata, 72 m. deep. August 4, 1930. 1 male.

Station 612, off northern Niigata-ken, 112 m. deep. August 13, 1930. 2 males and 4 females.

Station 616, north-west of mouth of the River Mogami, 106 m. deep. August 14, 1930. 1 male.

Station 621, north of mouth of the River Mogami, 93 m. deep. August 15, 1930. 1 male.

Station 623, south of Oga, 93 m. deep. August 15, 1930. 1 male.

Station 632, north of Oga, 71 m. deep. August 17, 1930. 1 male and 1 female.

Station 636, north of Oga, 115 m. deep. August 18, 1930. 1 female.

Species are small in size, but some females larger than others; dimensions as follows:

	female from Stat. 373	female from Stat. 473
Length of Carapace	25.0 mm.	24.8 mm.
Width of Carapace	35.7	35.3

DISTRIBUTION: Japan: Kôti and above localities. Depth: 68–324 m.

274. *Pilumnoplax inaequalis* n. sp.

(Text-fig. 63.)

LOC. Station 9, south of Inuboe-zaki, 238 m. deep. June 22, 1926. 2 females.

Station 193, off mouth of the River Tenryû, 265 m. deep. July 2, 1927. 1 female.

Station 194, coast of Maisaka, Sizuoka-ken, 192 m. deep. July 2, 1927. 2 females.

Station 278, Suruga Bay, 79 m. deep. July 2, 1928. 1 female.

Station 283, between Omae-zaki and Irô-zaki, 177 m. deep. July 4, 1928. 1 female.

Station 301, east of Ariake Bay, Kagosima-ken, 181 m. deep. July 12, 1928. 1 male.

Station 307, Bungo Strait, 165 m. deep. July 14, 1928. 1 male.

Station 316, Bungo Strait, 190 m. deep. July 16, 1928. 2 males.

Station 337, north-east of Asizuri-zaki, 130 m. deep. July 26, 1928. 1 male.

Station 356, near Siwo-misaki, 384 m. deep. August 8, 1928. 1 female.

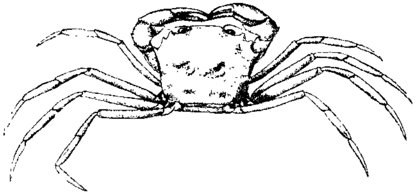
Station 413, south of Sata-misaki, Kagosima-ken, 249 m. deep. July 13, 1929. 1 female.

Station 417, southern coast of Satuma, Kagosima-ken, 192 m. deep. July 14, 1929. 2 males.

Station 421, south of Kosiki Isls., 307 m. deep. July 15, 1929. 1 male and 2 females.

Station 453, between Gotô Isls. and Saisyûtô Isl., 148 m. deep. July 23, 1929. 1 female.

Near *Pilumnoplax glaberrima* ORTMANN. Carapace somewhat uneven, with two well marked transverse carinae; the anterior on



Text-fig. 63. *Pilumnoplax inaequalis* n. sp. (×1).

the gastric and another on the cardiac region. Antero-lateral margin with three teeth, including extraorbital one; in these teeth the anterior two subequal in size and terminally rounded, while the posterior epibranchial is somewhat larger and more sharply pointed. In some young males from Stations 301, 307, 316 etc. posterior two teeth are acutely pointed. Front very slightly notched in the medial line. Chelipeds subequal; merus with a tooth on the superior margin, carpus with two teeth, an outer small one and an inner broad one, finger of left hand somewhat longer than that of right hand, in the latter it is nearly as long as the palm. On the inner surface of the hand there is no prominent protuberance. Succeeding four pairs of walking legs slender and similar in shape. All joints unarmed; terminal two joints are provided with series of small hairs on the upper and the lower margin. The fourth is the longest, third the next and fifth is longer than second. Abdomen in both sexes distinctly divided into seven segments.

Genus **LITOCHEIRA** KANAHAN.

275. Litocheira longipes (STIMPSON).

Pilumnoplax longipes, STIMPSON, 1907, p. 91.
Litocheira longipes, BALSS, 1922, p. 138.

LOC. *Station 295, north of Tanegasima Isl., 154 m. deep. July* 11, 1928. 1 egg-bearing female.

DISTRIBUTION: Japan: Ôsima, Kagosima and above locality.

Subfamily Gonoplacinae MIERS.

Genus **GONOPLAX** LEACH.

276. Gonoplax renoculis RATHBUN.

RATHBUN, *1914*, p. 145.

LOC. Station 103, east of Bôsyû, 117 m. deep. February 27, 1927. 1 female.

Station 113, south of Inuboe-zaki, 196 m. deep. March 2, 1927. 1 female.

Station 195, south-west of Hamana Lake, 172 m. deep. July 2, 1927. 2 males and 3 females.

Station 305, off southern Miyazaki-ken, 137 m. deep. July 12, 1928. 1 male and 2 females, 1 bears eggs.

Station 307, off southern Miyazaki-ken, 165 m. deep. July 14, 1928. 1 male and 4 females, 2 bear eggs.

Station 308, off southern Miyazaki-ken, 155 m. deep. July 14, 1928. 2 males and 2 egg-bearing females.

Station 337, north-east of Asizuri-zaki, 130 m. deep. July 26, 1928. 1 egg-bearing female.

Station 349, Kii Strait, 152 m. deep. August 1, 1928. 2 females, 1 bears eggs.

Station 360, south of Owase, Mie-ken, 123 m. deep. August 9, 1928. 1 male and 1 egg-bearing female.

Station 362, east of Owase, Mie-ken, 132 m. deep. August 9, 1928. 1 male and 1 female.

Station 453, between Saisyûtô Isl. and Gotô Isls., 148 m. deep. July 23, 1929. 1 female.

Station 464, between Tusima Isl. and Gotô Isls., 146 m. deep. July 24, 1929. 2 males and 5 females, 2 bear

eggs.

Station 478, east of Huzan, 101 m. deep. August 8, 1929. 1 male and 2 females.

Station 482, far north-west of Nagato, Yamaguti-ken, 139 m. deep. August 8, 1929. 1 male and 1 female.

Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 1 male and 1 female.

Station 486, far north of Nagato, Yamaguti-ken, 203 m. deep. August 11, 1929. 1 male.

Station 493, off Hamada, Simane-ken, 124 m. deep. August 12, 1929. 2 males.

Station 540, near Kyô-gasaki, 123 m. deep. August 25, 1929. 1 male.

The tooth on the lower margin of the orbit below, near the middle of the eye-stalk, is very obscure.

DISTRIBUTION: Southern Luzon, Philippine; Japan: above localities.

277. Gonoplax nipponensis n. sp.

(Text-fig. 64.)

LOC. Station 274, Suruga Bay, 51 m. deep. July 2, 1928. 1 female.

Station 286, Suruga Bay, 123 m. deep. July 4, 1928. 1 female.

Station 291, near Omae-zaki, 77 m. deep. July 5, 1928. 1 female.

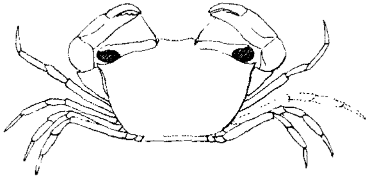
Station 420, south of Kosiki Isls., 132 m. deep. July 16, 1929. 1 male and 1 female.

Station 465, north of Gotô Isls., 106 m. deep. July 24, 1929. 1 female.

Station 485, east of Misima Isl., 93 m. deep. August 11, 1929. 1 female.

Carapace smooth, moderately convex antero-posteriorly. Front truncated, rather concave, distinctly wider than one fourth of carapace, which is broadest at the extra-orbital tooth. The dorsal margin of the orbit is a little sinuated, the lateral margins of the carapace are obliquely conversing backwards and provided with no tooth. Eye-stalk cylindrical; first antenna transverse; second antenna long

flagellated; epistom short. The buccal area is anteriorly broad; the external maxillipeds gaping in the middle, with the merus a little



Text-fig. 64. *Gonoplax nipponensis* n. sp. (×5)

dilated at the antero-external angle. Chelipeds of moderate size, subequal and smoothly surfaced; carpus rounded at internal margin; palm moderately compressed, as long as finger. Succeeding pairs of pereiopods slender, without hair or teeth. Abdomen in both sexes seven-segmented.

Near *Gonoplax sinuatifrons* MIERS (1886, p. 246, Pl. 20, Fig. 2), but carapace with lateral margins somewhat more arcuate. Legs without teeth on merus.

Genus OMMATOCARCINUS WHITE.

278. Ommatocarcinus sp.

(Text-fig. 65.)

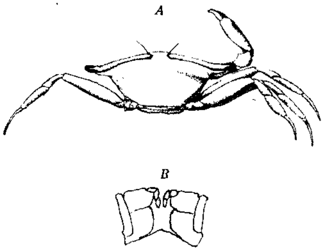
LOC. Station 347, Kii Strait, 126 m. deep. July 29, 1928. 1 female.
Station 349, Kii Strait, 152 m. deep. August 1, 1928. 1 male.
Station 426, north of Kosiki Isls., 99 m. deep. July 26, 1929. 1 female.

Carapace much laterally dilated at the extraorbital angle and roughly rhomboidal in shape, wider than twice the length; front narrow, constricted between eye-peduncles. Orbit broad, occupies the whole width of anterior margin, except front. Lateral margin concave. Surface naked, an obtuse transverse ridge is a little in front of the middle of the carapace. A prominent ridge on pterygostomian region.

Ophthalmopod long exceeds extraorbital angle. Antennae well developed. The buccal area subquadrate, wider in front; external maxillipeds gaping in the middle. Cheliped rather long; merus unarmed; palm compressed, longer than finger. Posterior legs rather long and subequal in length, surface smooth.

I examined another male specimen of this species from Sagami Bay.

The species may be near *O. macgillivrayi* WHITE (1852, p. 393, Pl. 5, Fig. 1), but I had no opportunity of consulting the original description.



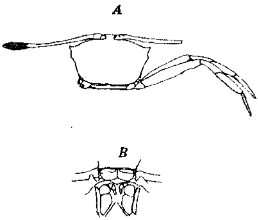
Text-fig. 65. *Ommatocarcinus sp.*
A, Entire animal (×2). *B*, buccal area (×5).

279. Ommatocarcinus fibriophthalmus n. sp.

(Text-fig. 66.)

LOC. Station 464, between Tusima Island and Gotô Isls., 146 m. deep. July 24, 1929. 1 female.

This extraordinary species is distinguishable in the enormously long eye-stalk, which is much longer than the width of the carapace. The carapace is granular surfaced and roughly trapezoid in shape. The lateral margin converging posteriorly, is bluntly pointed behind the extraorbital angle, where it is more acutely pointed. The front deflexed and constricted between the eye-stalk. Legs unfortunately missing in the specimen but posterior two on the right side. In these two, posterior a



Text-fig. 66. *Ommatocarcinus fibriophthalmus* n. sp.
A, Entire animal (×1.5).
B, Antennal buccal region (×3).

little longer than anterior. The abdomen, in female, is seven-segmented and occupies the whole space between the bases of the last pair of legs.

Subfamily Rhizopinae STIMPSON.

Genus **CERATOPLAX** STIMPSON.

280. *Ceratoplax ciliata* STIMPSON.

STIMPSON, 1858, p. 96; MIERS, 1886, p. 234, Pl. 19, Fig. 3; ALCOCK, 1900, p. 320; TESCH, 1918, p. 204, Pl. 11, Fig. 2.

LOC. Station 300, southern Bungo Strait, 110 m. deep. July 11, 1928. 2 females.
Station 349, Kii Strait, 152 m. deep. August 1, 1928. 4 males and 2 females.

DISTRIBUTION: Andaman Sea; Torres Strait; Gulf of Siam; China Sea: Japan: above localities.

Genus **TYPHROCARCINUS** STIMPSON.

281. *Typhrocarcinus villosus* STIMPSON.

STIMPSON, 1858, p. 96; MIERS, 1879, p. 40; WALKER, 1890, p. 110, Pl. 9, Figs. 6–8; ORTMANN, 1894, p. 689; TESCH, 1918, p. 209, Pl. 13, Fig. 2.

LOC. Station 372, south of Lake Hamana, 466 m. deep. August 13, 1928. 1 female.
Station 417, southern coast of Satuma, Kagosima-ken, 192 m. deep. July 14, 1929. 1 male.
Station 483, north of Nagato, Yamaguti-ken, 130 m. deep. August 9, 1929. 2 egg-bearing females.
Station 524, off Tottori-ken, 88 m. deep. August 23, 1929. 1 female.

DISTRIBUTION: Bay of Bengal; Sumba; Timor; Siam; Singapore; Hongkong; Japan: Tokyo Bay and above localities.

Genus **TYPHROCARCINODES** ALCOCK.

282. *Typhrocarcinodes hirsutus* (BORRADAILE).

Caecopilumnus hirsutus, BORRADAILE, 1903, p. 269, Fig. 59.
Typhrocarcinodes hirsutus, TESCH, 1918, p. 228, Pl. 15, Fig. 3.

LOC. Station 300, southern Bungo Strait, 110 m. deep. July 11, 1928. 1 male.

Station 470, between Simonoseki and Iki Isl., 37 m. deep. July 25, 1929. 1 male.

Station 521, between Mihonoseki and Oki Isls., 86 m. deep. August 23, 1929. 1 female.

DISTRIBUTION: Maldives; Madura Bay; Japan: above localities.

Genus TYPHROCARCINOPS RATHBUN.

283. *Typhrocarcinops ocularia* RATHBUN.

RATHBUN, 1914, p. 153.

LOC. Station 471, north-west of Nagato, Yamaguti-ken, 90 m. deep. July 27, 1929. 2 males and 3 females.

Station 520, north of Mihonoseki, Simane-ken, 75 m. deep. August 23, 1929. 3 males and 1 female.

Chelipeds subequal in female and more hairy than those of male.

DISTRIBUTION: Philippine Islands (50 fms); Japan; above localities.

Genus HEPHTHOPELTA ALCOCK.

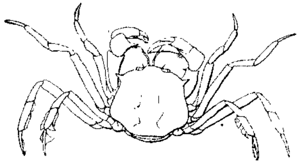
284. *Hephthopelta aurita* RATHBUN.

(Text-fig. 67.)

RATHBUN, 1932, p. 34.

LOC. Station 213, Kii Strait, 353 m. deep. July 18, 1927. 1 egg-bearing female.

Station 342, west of Muroto-zaki, 288–527 m. deep. July 28, 1928. 1 female.



Text-fig. 67. *Hephthopelta aurita* RATHBUN (×1.5).

The enormously strong tooth on the antero-lateral margin of the carapace is the characteristic of the species, and it directs obliquely outwards and upwards, and a little forwards. Chelipeds subequal; merus with three

tubercular teeth on inferior outer margin and one more tooth near distal end of inner margin; carpus strongly produced on inner margin; chela compressed, finger long.

DISTRIBUTION: Japan: Omae-zaki and above localities.

Genus **CAMATOPSIS** ALCOCK.

285. Camatopsis rubida ALCOCK.

ALCOCK, 1899, p. 76, Pl. 4, Fig. 3; DOFLEIN, 1904, p. 121; TESCH, 1918, p. 235, Pl. 16, Fig. 3.

LOC. Station 187, near Omae-zaki, 128 m. deep. June 30, 1927. 1 female.

Station 221, north-west of Muroto-zaki, 209 m. deep. July 20, 1927. 1 male.

Station 244, Sagami Bay, 135 m. deep. November 7, 1927. 1 male.

Station 259, Suruga Bay, 188 m. deep. November 15, 1927. 1 male.

Station 277, Suruga Bay, 91 m. deep. July 2, 1928. 1 female.

Station 300, southern Bungo Strait, 110 m. deep. July 11, 1928. 3 males and 1 female.

Station 305, east of southern Miyazaki-ken, 137 m. deep. July 12, 1928. 1 male.

Station 307, off southern Miyazaki-ken, 165 m. deep. July 14, 1928. 1 male and 1 female.

Station 324, southern Bungo Strait, 106 m. deep. July 21, 1928. 1 female.

Station 332, off Maisaka, Sizuoka-ken, 123 m. deep. July 2, 1928. 1 female.

Station 339, south of Kôti, 106 m. deep. July 28, 1928. 1 male.

Station 341, south of Kôti, 126 m. deep. July 28, 1928. 2 males and 1 female.

Station 347, southern Kii Strait, 126 m. deep. July 29, 1928. 1 male and 1 female.

Station 365, south-east coast of Mie-ken, 93 m. deep. August 10, 1928. 1 male and 1 egg-bearing female.

Station 373, south of Lake Hamana, 128 m. deep. August

13, 1928. 1 female.
Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 egg-bearing female.
Station 484, north of Nagato, Yamaguti-ken, 93 m. deep. August 9, 1929. 1 male and 2 females, 1 bears eggs.
Station 485, east of Misima Isl., 93 m. deep. August 11, 1929. 1 female.
Station 520, north of Mihonoseki, Simane-ken, 75 m. deep. August 23, 1929. 1 male and 2 females.
Station 546, Wakasa Bay, 101 m. deep. July 20, 1930. 1 male and 1 female.

The present specimens coincide with the description and the figures given by TESCH "Form A".

DISTRIBUTION: Andaman Sea; Sumatra; Siam; Java; Kwandan Bay; *Ki Islands; Rotti; Flores; Sumbawa; Japan: above localities.*

Genus **MEGAESTHESIUS** RATHBUN.

286. ? Megaesthesius sp.

(Text-fig. 68.)

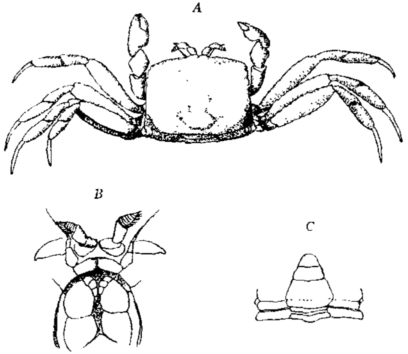
LOC. Station 300, southern Bungo Strait, 110 m. deep. July 11, 1928. 1 male.
Station 413, south of Sata-misaki, Kagosima-ken, 249 m. deep. July 13, 1929. 1 male.

The specimen referable to this genus is not identified with the specific name, as I was unable to consult the original description and the figure (RATHBUN, 1910). I want here to describe the specimens before me.

Carapace subquadrate, strongly arcuated antero-posteriorly, surface areolated by shallow sulci. Front nearly one fifth as wide as carapace, two lobed, slightly sulcated in the middle. Orbit scarcely noticeable in dorsal view, nearly as wide as frontal lobe. Anterolateral margin almost transverse, slightly retreating backwards at the lateral corner, where obtusely angulated with the subparallel postero-lateral margin, which is provided with two or three shallow notches.

Eyes much retreated, not pigmented. Two pairs of antennae well developed, especially first pair with two stout peduncular segments,

but scarcely as wide as frontal lobe. Epistom narrow, longitudinally sulcated in the middle. External maxilliped with basi-ischium joint



Text-fig. 68. ? *Megaesthesius sp.*
A, Entire animal (×5). *B*, Antennal, buccal region (×10). *C*. Male abdomen and a part of sternum (×5).

broad, narrow merus, and rather stout palp. Chelipeds of male subequal; chela compressed, finger longer than palm. Posterior four pairs of legs nearly shaped; merus with anterior and posterior margins slightly serrated.

Abdomen in male narrow, six-jointed.

Subfamily Prionoplacinae ALCOCK.

Genus SPEOCARCINUS STIMPSON.

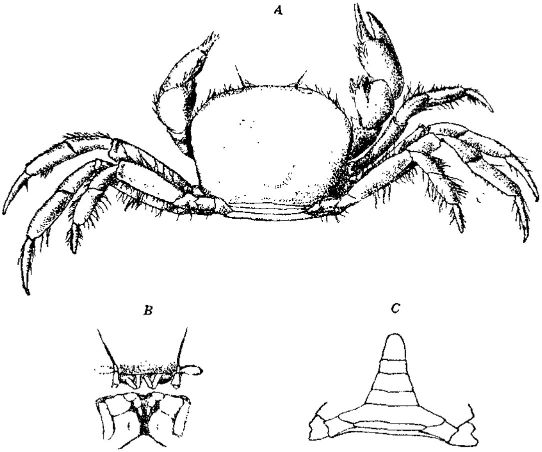
287. Speocarcinus laevimarginatus n. sp.

(Text-fig. 69.)

LOC. Station 417, south of Satuma, Kagosima-ken, 192 m. deep. July 14, 1928. 1 male.

The species is distinctly different from other species of this genus in the smooth margin of the carapace, which is slightly carinated on the antero-lateral margin. The lateral margins are a little

converged posteriorly. The surface is smooth and covered with short hairs. The front is about one third as wide as the carapace. Along the frontal and the antero-lateral margins there are rather long hairs.



Text-fig. 69. *Speocarcinus lacvimarginatus* n. sp.
A, Entire animal (×4). *B*, Antennal, buccal region (×4).
C, Male abdomen and a part of sternum (×5).

The abdomen in male consists of seven segments, in which the first is the widest of all and occupies the whole space between the bases of the last pair of legs. The second segment is much narrower, while the third is wide, but does not occupy the whole width of the sternum.

The first antenna is transversely plicated. In the second antenna the basal joint scarcely reaches the front, the flagellum is rather long. The buccal area is broad anteriorly; the merus of the third maxilliped is dilated at the antero-external corner. The chelipeds are subequal, smoothly surfaced and covered with short hairs, while the carpus and the palm are provided with more or less longer hairs

on the upper margins. The succeeding pairs of legs are similar in feature and the penultimate pair is the longest. The dactylus of the last is somewhat reversely curved.

Family **Palicidae** ALCOCK.

Genus **PALICUS** PHILIPPI.

288. Palicus oahuensis RATHBUN.

RATHBUN. 1906, p. 836, Pl. 7, Fig. 4; BALSS, 1922, p. 120, Fig. 6.

LOC. Station 109, south-east of Inuboe-zaki, 123 m. deep. March 2, 1927. 1 female.
Station 283, between Omae-zaki and Iró-zaki, 177 m. deep. December 4, 1927. 1 egg-bearing female.
Station 440, south-west of Gotô Isls., 152 m. deep. July 19, 1929. 1 male.

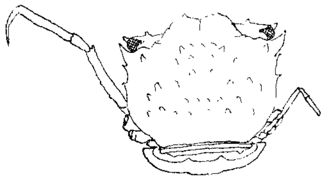
DISTRIBUTION: Hawaii; Japan: Sagami Bay and above localities. Depth: 123–358 m.

289. Palicus kyusyuensis n. sp.

(Text-fig. 70.)

LOC. Station 423, south of Kosiki Isls., 243 m. deep. July 15, 1929. 1 female.

Carapace rather quadrate, tubercular, but not strikingly convex; regions not deeply marked; extraorbital tooth prominent, produced antero-externally. Front broad, bilobed; each lobe convex, median sinus shallow, but distinct. Some tubercular teeth on supraorbital margin. Two small teeth on the lateral margin behind the extra-orbital tooth. Tubercles on the gastric region are roughly arranged in three rows; anterior five, middle four and posterior two. Five or six tubercles on the branchial and seven or eight on the cardiac region. Chelipeds



Text-fig. 70. *Palicus kyusyuensis* n. sp. (×8)

missing in the specimen. Next leg of left side (right one missing) slender, longer than width of carapace; merus somewhat tubercular, distally obtusely pointed. Succeeding two pairs missing at all. Last leg (left one missing) very slender, with dactylus very short.

Abdomen of female very broad; each of first four somites transversely carinated in the middle, that of the third somite is the most prominent. Fourth, fifth and sixth somites are imperfectly fused. Dimensions of the specimen as follows:

Length of carapace in the middle line	3.2 mm.
Width of carapace at the extra-orbital tooth	4.3

Family **Retroplumidae** GILL.

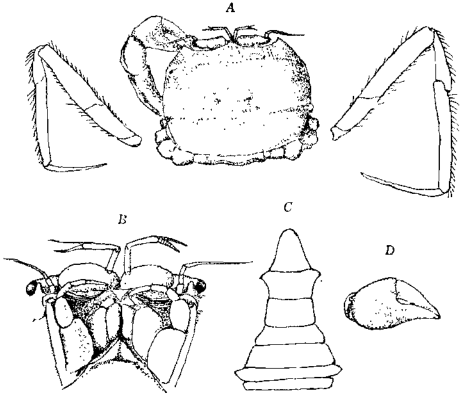
Genus **RETROPLUMA** GILL.

290. Retropluma denticulata RATHBUN.

(Text-fig. 71.)

RATHBUN, 1932, p. 33.

LOC. Station 310, east of southern Miyazaki-ken, 110 m. deep.



Text-fig. 71. *Retropluma denticulata* RATHBUN.
A, Entire animal (×5). *B*, Antennal, buccal region (×10). *C*, Abdomen of male (×10). *D*, Chela of right side (×5).

July 14, 1928. 1 male.
Station 422, west of Kagosima-ken, 88 m. deep. July 15, 1929. 1 egg-bearing female.
Station 426, north of Kosiki Isls., 99 m. deep. July 16, 1929. 1 female.
Station 493, off Hamada, Simane-ken, 124 m. deep. August 12, 1929. 1 female.
Station 504, near Oki Isls., 106 m. deep. August 18, 1929. 1 male and 1 female.

Chelipeds subequal, surface smooth; finger of chela longer than palm, a small area gaping at the proximal part; merus and carpus with upper margins hairy. Legs fallen off, but in the remaining legs they are unarmed, long and slender.

Abdomen seven-segmented in both sexes; in male, second segment broadest, penultimate laterally dilated near the distal end; in female the basal segment the broadest, successively decreasing in with to the terminal segment and it is subtriangular in shape.

DISTRIBUTION: Japan: Suruga Bay and above localities.

Family **Pinnotheridae** M.-E.

Subfamily Pinnotherinae ALCOCK.

Genus **PINNOTHERES** LATREILLE.

291. ***Pinnotheres pholadis*** DE HAAN.

DE HAAN, 1835, p. 63, Pl. 16, Fig. 7; TESCH, 1918, p. 252; BALSS, 1922, p. 139; YOKOYA, 1928, p. 773.
Pinnotheres pisoides, ORTMANN, 1894, p. 698, Pl. 23, Fig. 11.

LOC. Station 370, south of Atumi, Aiti-ken, 91 m. deep. August 10, 1928. 1 male.

DISTRIBUTION: Japan: Mutu Bay, Tokyo Bay, Sagami Bay, Nagasaki and above locality.

Subfamily Pinnotherelinae ALCOCK.

Genus **PINNIXA** WHITE.

292. ***Pinnixa occidentalis*** RATHBUN.

RATHBUN, 1893, p. 248; 1917, p. 155, Pl. 34, Fig. 1, Text-figs. 95, 97; HOLMES, 1900, p 89; SCHMITT, 1921, p. 262, Text-fig. 156; YOKOYA, 1928, p. 775, Text-fig. 6.
Pinnixa californiensis, RATHBUN, 1893, p. 249; HOLMES, 1900, p. 90.

LOC. Station 101, west of Kinkazan, 40 m. deep. November 10 1926. 50 males and 23 females.
Station 102, south-west of Kinkazan, 37 m. deep. No vember 10, 1926. 2 females, 1 bears eggs.
Station 143, east of Siwoya-zaki, 132 m. deep. Novembe 30, 1925. 1 female.
Station 164, east of Owase, Mie-ken, 276 m. deep. Augus 1928. 1 female.

DISTRIBUTION: Pacific coast of North America; Japan: Mutu Bay and above localities.

III. Distribution.

As I suggested in the previous papers (1928, 1930), some specie of Decapod Crustaceans of Japan distribute northwards from centra Japan, vaguely speaking, to Bering Sea, Alaska and west of America etc., while others distribute southwards to the Malayan Archipelago Indian Ocean and Australia, etc. Now, examining the distribution of the species, described above, we can learn that none of th northwards distributed species were collected from the south o Kyûsyû and the southwards distributed species rarely occur north o Tugaru Strait. The results are summarized in the following tables

TABLE I.

The list of the northwards distributed species, showing the southern limit of distribution.

Species	Southern limit of distribution	
	East or Pacific side	West or continental side
Cancer gibbosulus (DE HAAN)	Bungo Strait	Gotô Isls.
Chionecetes opilio (FABR.)	Kinkazan	Nagato
* ? *Crangon abyssorum* RATHBUN	Kôti	—
* *Crangon communis* RATHBUN	Todo-saki	Toyama Bay
Doclea bidentata (A. M.-E.)	Inuboe-zaki	Mutu Bay
Eupagurus cavimanus MIERS	Siwoya-zaki	Tottori-ken
Eupagurus hirsutiusculus (DANA)	—	Tugaru Strait
Eupagurus ochotensis BRANDT	Inuboe-zaki	Sado Isl., Nagasaki
Eupagurus pectinatus STIMPSON	—	Tusima Isl.

TABLE I. (*Continued*)

Species	Southern limit of distribution	
	East or Pacific side	West or continental side
Eupagurus trigonocheirus STIMPSON	Inuboe-zaki	Kosiki Isls.
Lithodes aequispinus BENEDICT	Siwoya-zaki	—
Nectocrangon lar (OWEN)	—	Toyama Bay
Oregonia gracilis DANA	Inuboe-zaki	Tusima Isl.
* *Pandalus borealis* KRÖYER	—	Hukui-ken,
Pandalus hypsinotus BRANDT	—	Toyama Bay, Tusima Isl., Nagasaki
Pandalus platyceros BRANDT	—	Sado, Nagasaki
Paracrangon echinata DANA	Todo-saki, Sagami Bay?	Kyô-gasaki, Tusima
Pinnixa occidentalis RATHBUN	Owase	Mutu Bay
* *Spirontocaris biunguis* RATHBUN	—	Sado Isl.
Spirontocaris camtschatica (STIMPSON)	Aiti-ken	—
Spirontocaris groenlandica (FABR.)	—	Hukui-ken
* *Spirontocaris pusiola* (KRÖYER)	—	West of Tugaru Str.
* *Spirontocaris unalaskensis* RATHBUN	—	Yamaguti-ken
Trachicarcinus balssi RATHBUN ?	not collected betw. Siriya-zaki & Tokyo	—

The species, which have not hitherto been known from Japan, are marked with *.

TABLE II.

The southwards distributed species, showing the northern limit of distribution.

Species	Northern limit of distribution	
	East or Pacific side	West or continental side
Actaea affinis (DANA)	Kii Strait	—
Actaea pilosa STIMPSON	—	Tusima Isl.
Actaea rufopunctata (M.-E.)	Tokyo Bay	—
Actaea rüppelli (KRAUSS)	Inuboe-zaki	Nagasaki
Actaea savignyi pura STIMPSON	Inuboe-zaki	Nagasaki
Actumnus setifer (DE HAAN)	Tokyo Bay	Nagasaki
Actumnus squamosus (DE HAAN)	Siwoya-zaki	Nagato
Aegeon habereri (DOFLEIN)	Sagami Bay	Oki Isls.
* *Alpheus gracilipes* STIMPSON	Tanegasima Isl.	Kosiki Isls.

TABLE II. *(Continued)*

Species	Northern limit of distribution	
	East or Pacific side	West or continental side
Alpheus ventrosus M.-E.	Tokyo Bay	North of Tusima Isl.
Aniculus aniculus FABRICIUS	Tokyo Bay	—
Arcania globata STIMPSON	Sagami Bay	Maizuru
Arcania undecimspinosa DE HAAN	Tokyo Bay	Kyô-gasaki
Arctus cultrifer ORTMANN	Inuboe-zaki	—
* *Camatopsis rubida* ALCOCK	Sagami Bay	Wakasa Bay
Carcinoplax longimanus (DE HAAN)	Sagami Bay	Tugaru Strait
Carpilodes venosus (MILNE-EDWARDS)	Tokyo Bay	—
* *Ceratoplax ciliata* STIMPSON	Kii Strait	—
Ceratopenaeus dalei (RATHBUN)	Kinkazan	Tugaru Strait
Ceratopenaeus mogiensis (RATHBUN)	Sagami Bay	Nagasaki
Charybdis miles DE HAAN	Tokyo Bay	Kosiki Isls.
Charybdis (Goniohellenus) truncatus (FABRICIUS)	Tokyo Bay	Nagasaki
Charybdis (Gonioneptunus) subornata ORTMANN	Siwoya-zaki	Oga
* *Cosmonotus grayii* AD. & WHITE	Sagami Bay	Oki Isls.
Cryptocnemus obolus ORTMANN	Sagami Bay	—
* *Cryptodromia incisa* HENDERSON	Suruga Bay	—
* *Cyrtomaia horrida* RATHBUN	Omae-zaki	—
Dorippe granulata DE HAAN ?	Todo-saki	Aomori-ken
Dynomene hispida DESM.	Tanabe	—
Ebalia jordani RATHBUN	Suruga Bay	—
Ethusa sexdentata (STIMPSON)	Inuboe-zaki	Tusima Isl.
Eumunida smithii HENDERSON	Sagami Bay	Gotô Isls.
Galathea acanthomera STIMPSON	Tokyo Bay	Maizuru
Galathea australiensis STIMPSON	Sagami Bay	Tusima Isl.
* *Galathea latirostris* DANA	Omae-zaki	Gotô Isls.
Galathea subsquamata STIMPSON	Inuboe-zaki	—
Glyphocrangon hastacauda BATE	Tokyo Bay	—
Haliporus sibogae DE MAN	Sizuoka-ken	—
Heterocarpus ensifer A. M.-E.	Sagami Bay	—
Heteropanope glabra STIMPSON	Kôti	—
Homola barbata orientalis HENDERSON	Sagami Bay	—
Homola (Parahomola) japonica PARISI	Sagami Bay	—
Ibacus ciliata (V. SIEBOLD)	Tokyo Bay	—
Latreillia valida DE HAAN	Sagami Bay	Tusima Isl.
Latreillopsis bispinosa HENDERSON	Sagami Bay	—

TABLE II. (*Continued*)

Species	Northern limit of distribution: East or Pacific side	Northern limit of distribution: West or continental side
Leptochela gracilis STIMPSON	Todo-saki	Toyama Bay
Leptodius exaratus (MILNE-EDWARDS)	Tokyo Bay	Nagato
* *Leucosia australiensis* MIERS	Omae-zaki	—
* *Leucosia haematosticta* AD. & WHITE	Bungo Strait	—
Leucosia longifrons DE HAAN	Inuboe-zaki	Niigata-ken
Leucosia obtusifrons DE HAAN	Sagami Bay	Nagato
Leucosia rhomboidalis DE HAAN	—	Maizuru
Lophoxanthus scaberrimus (WALKER)	Kii Strait	Nagasaki
Lyreidus tridentatus DE HAAN	Inuboe-zaki	Toyama Bay
Maja miersi WALKER	Sagami Bay	Gotô Isls.
Mixtopagurus spinosus (HENDERSON)	Tokyo Bay	—
Munida andamanica ALCOCK	Sagami Bay	—
Munida japonica STIMPSON ?	Siriya-zaki	Tugaru Strait
* *Munida scabra* HENDERSON	Inuboe-zaki	Tusima Isl.
Munidopsis trifida HENDERSON	Suruga Bay	—
Mursia armata DE HAAN	Tokyo Bay	Gotô Isls.
Mursia armata curtispina MIERS	Inuboe-zaki	Toyama Bay
Myra fugax (FABRICIUS)	Sagami Bay	?
Naxia hystrix MIERS	Sagami Bay	West of Kyûsyû
Neptunus pelagicus (LINNÉ)	Sagami Bay	Nagasaki
Neptunus trituberculatus MIERS	Kinkazan	Mutu Bay
Neptunus (Hellenus) hastatoides (FABR.)	Tokyo Bay	Nagasaki
Nika edulis RISSO	Tokyo Bay	Nagasaki
Notopus dorsipes (FABRICIUS)	Sagami Bay	—
* *Notopus ovalis* HENDERSON	Suruga Bay	Hukui-ken
Ogyris orientalis STIMPSON	Hukusima-ken	Simane-ken
Oncinopus aranea DE HAAN	Sagami Bay	—
* *Oplophorus gracilirostris* M.-E.	Kii Strait	—
Oreophorus rugosus STIMPSON	Kagosima	—
* *Ovalipes iridescens* (MIERS)	Bungo Strait	Kosiki Isls.
Ovalipes trimaculatus (DE HAAN)	Kinkazan	Tugaru Strait
Paguristes pussilus HENDERSON	Sagami Bay	—
Pagurus arrosor (HERBST)	Kinkazan	Noto
Pagurus impressus DE HAAN	Sagami Bay	Tusima Isl.
Palicus oahuensis RATHBUN	Inuboe-zaki	Tusima Isl.
Parapagurus pilosimanus SMITH	South of Tokyo Bay	—
Parapenaeus fissurus (BATE)	Tokyo Bay	—

TABLE II. (*Continued*)

Species	Northern limit of distribution	
	East or Pacific side	West or continental side
* *Parapenaeus rectacutus* (BATE)	Sizuoka-ken	—
* *Parathranites orientalis* MIERS	Suruga Bay	Hukui-ken
Pariphiculus coronatus ALC. & ANDERS.	Tokyo Bay	Tusima Isl.
Pariphiculus agariciferus IHLE	Siwo-misaki	—
? *Pasiphea sivado* (RISSO)	Bôsyû	Toyama Bay
Penaeopsis ensis (DE HAAN)	Mie-ken	—
Penaeus semisulcatus DE HAAN	Tokyo Bay	—
* *Petrolisthes militaris* (HELLER)	Kagosima-ken	—
Pilumnoplax americana RATHBUN	Sagami Bay	—
Pilumnoplax vestita (DE HAAN)	Tokyo Bay	Oga
Pilumnus hirsutus STIMPSON	Siwoya-zaki	Mutu Bay
Pilumnus marginatus STIMPSON	Sagami Bay	—
* *Pilumnus vespertilio* (FABRICIUS)	Omae-zaki	—
* *Pleisticantha moselei* (MIERS)	Inuboe-zaki	Kosiki Isls.
Plesionika binoculus (BATE)	Kii Strait	Simane-ken
* *Plesionika brevirostris* BATE	Owase	—
Plesionika martia (A. MILNE-EDWARDS)	Sagami Bay	Gotô Isls.
* *Plesionika rostricrescentis* (BATE)	Omae-zaki	—
* *Porcellana picta* STIMPSON	Mie-ken	—
Portunus corrugatus strigilis STIMPSON	Inuboe-zaki	Aomori-ken
* *Pugettia veltima* MIERS	Omae-zaki	—
Ranina ranina LINNÉ	Sagami Bay	—
* *Raninoides personatus* WHITE	Siwo-misaki	—
Solenocera distincta (DE HAAN)	Inuboe-zaki	Toyama Bay
Spongicola venusta DE HAAN	Sagami Bay	—
Stylodactylus bimaxillaris BATE	Sagami Bay	Gotô Isls.
Synalpheus gravieri COUT.	Tokyo Bay	Nagato
Thalamita prymna (HERBST)	Tokyo Bay	—
Trachypenaeus curvirostris (STIMPSON)	Todo-saki	West of Hokkaidô
Tymolus uncifer (ORTMANN)	Todo-saki	Noto
* *Typhrocarcinodes hirsutus* (BORR.)	Bungo Strait	Oki Isls.
* *Typhrocarcinodes ocularia* (RATHBUN)	—	Oki Isls.
Typhrocarcinus vellosus STIMPSON	Tokyo Bay	Tottori-ken
Uroptychus nitidus occidentalis FAXON	Sagami Bay	Tusima Isl.
* *Xanthias lamarckii* (MILNE-EDWARDS)	Kii Strait	—
* *Xanthias tuberculidens* RATHBUN	Muroto-zaki	—

* The species, which have not hitherto been known from Japan, are marked with.

Other species not listed in the above two tables have hitherto been known only from Japanese waters. They are shown in the tables III and IV. The examination of their distributions again suggests us that some of the species have southern distribution and may distribute southwards from Japan, and others are in contrast with them.

TABLE III.

The list of the species, which may distribute northwards from Japan, showing the southern limit of distribution.

Species	Southern limit of distribution	
	East or Pacific side	West or continental side
Chorilia longipes japonica MIERS	Sagami Bay	—
Crangon affinis DE HAAN ?	Inland Sea	Gotô Isls.
Crangon laevis n. sp.	—	Aomori-ken
Crangon nipponensis n. sp.	Siwoya-zaki	—
Crangon trigonorostris n. sp.	Siwoya-zaki	—
Ctenocheles balssi KISHINOUYE	—	Wakasa Bay
Dorippe japonica DE HAAN	Inland Sea	—
Eupagurus anomalus BALSS	Inuboe-zaki	Sado Isl.
Eupagurus barbatus ORTMANN	Sagami Bay	—
Eupagurus constans STIMPSON	Sizuoka-ken	Nagasaki
Eupagurus japonicus STIMPSON ?	Tokyo Bay	Tusima Strait
Eupagurus lanuginosus (DE HAAN)	Sagami Bay	Tugaru Strait
Galathea integra BENEDICT ?	Kagosima-ken	Kagosima-ken
Gomeza distincta (DE HAAN)	Sagami Bay	Nagato
Herbstia japonica n. sp.	Inuboe-zaki	—
Nectocrangon sadoensis n. sp.	—	Sado Isl.
Nectocrangon toyamaensis n. sp.	—	Toyama Bay
Oregonia mutsuensis YOKOYA	Siwoya-zaki	Mutu Bay
Pandalus nipponensis n. sp. ?	Owase	—
Paraspirontocaris kishinouyei YOKOYA	Aiti-ken ?	Noto
Podocatactes hamifer ORTMANN ?	Kôti	Kosiki Isls.
Pugettia quadridens (DE HAAN) ?	Kagosima-ken	Corea Strait
Sclerocrangon angusticauda (DE HAAN)?	Sagami Bay	Nagasaki
Sclerocrangon gasuyebi n. sp.	—	Toyama Bay
Scyra compressipes STIMPSON	Sagami Bay	Oga
Sergestes nipponensis n. sp.	Sagami Bay	—
Spirontocaris geniculata (STIMPSON)	Inland Sea (Seto)	Oga

TABLE III. *(Continued)*

Species	Southern limit of distribution	
	East or Pacific side	West or continental side
Spirontocaris gibberosa n. sp.	Siwoya-zaki	—
Spirontocaris gracilirostris (STIMPSON)	Sagami Bay	Oga
Spirontocaris leptognatha (STIMPSON)	Todo-saki	—
Spirontocaris minuta YOKOYA	—	Sado Isl.
Spirontocaris mororani RATHBUN	Todo-saki	Oga
Spirontocaris spathulirostris n. sp.	Todo-saki	Tusima Isl.

TABLE IV.

The species, which seem to have southern distribution, showing the northern limit of the distribution.

Species	Northern limit of distribution	
	East or Pacific side	West or continental side
Acantholithus hystrix (DE HAAN)	Sagami Bay	—
Achaeus japonicus (DE HAAN)	Tokyo Bay	Tusima Isl.
Achaeus robustus n. sp.	Bungo Strait	—
Achaeus spinosus MIERS	Sagami Bay	Gotô Isls.
Achaeus stenorhynchus RATHBUN	—	Gotô Isls.
Aegeon obsoletum BALSS	Sagami Bay	Oki Isls.
Arcania undecimspinosa elongata n. var.	Suruga Bay	—
Arctus rugosus n. sp.	*Bungo Strait*	—
Aristeus japonicus n. sp.	Owase	—
Axius (Eiconaxius) farreae ORTMANN	Tokyo Bay	Gotô Isls.
Axius habereri BALSS	Siwoya-zaki	Tusima Strait
Axius miyazakiensis n. sp.	Miyazaki-ken	—
Axius soyoi n. sp.	Siwoya-zaki	Tusima Isl.
Callianassa subterranea japonica ORTM.	Sagami Bay	Tugaru Strait
Cancer tumifrons n. sp.	Sagami Bay	Gotô Isls.
Catapagurus doederleini DOFLEIN	Siwoya-zaki	—
Catapagurus japonicus n. sp.	Sagami Bay	Nagasaki
Ceratopagurus pilosimanus n. sp.	Kii Strait	—
Cervimunida princeps BENEDICT	Kinkazan	Yamaguti-ken
Chlorinoides brevispinosa n. sp.	Kii Strait	—
Crangon geniculata n. sp.	Kii Strait	—

TABLE IV. *(Continued)*

Species	Northern limit of distribution	
	East or Pacific side	West or continental side
Crangon longirostris n. sp. ?	Owase	—
Cryptodromia ihlei BALSS	Tokyo Bay	Nagasaki
Cryptodromia nipponensis n. sp.	Kii Strait	—
Cyrtomaia platypes n. sp.	Kii Strait	Tusima Isl.
Cyrtomaia septenspinosa RATHBUN	Bôsyû	Tusima Isl.
Dromia pseudogibbosa PARISI	Sagami Bay	Tugaru Strait
Dynomene tanensis n. sp.	Tanegasima Isl.	—
Ebalia japonica RATHBUN	Todo-saki	Tugaru Strait
Ebalia longimana ORTMANN	Tokyo Bay	Wakasa Bay
Ebalia rugosa n. sp.	Suruga Bay	Gotô Isls.
Ebalia scabriscula ORTMANN	Sagami Bay	Gotô Isls.
Ebalia sikokuensis n. sp.	Bungo Strait	—
Ebalia tuberculata n. sp.	Kii Strait	Kosiki Isls.
Erithropenaeus acclivis (RATHBUN)	Kii Strait	Nagasaki
Erithropenaeus akayebi (RATHBUN)	Kii Strait	Mutu Bay
Eupagurus brevimanus n. sp.	Siwoya-zaki	—
Eupagurus conformis (DE HAAN)	Kinkazan	Nagato
Eupagurus dubius ORTMANN	Tokyo Bay	Tusima
Eupagurus gracilipes n. sp.	Kii Strait	—
Eupagurus nipponensis n. sp.	Inuboe-zaki	Tugaru Strait
Eupagurus obtusifrons ORTMANN ?	Siwoya-zaki	Tugaru Strait
Eupagurus ophthalmicus ORTMANN	Sagami Bay	Oga
Eupagurus similis ORTMANN	Siwoya-zaki	—
Eupagurus triserratus ORTMANN	Sagami Bay	Tottori-ken
Eurinome reini BALSS ?	Sagami Bay	Hukui-ken
Galathea multilineata BALSS	Sagami Bay	—
Galathea pubescens STIMPSON	Sagami Bay	Tugaru Strait
Gonoplax nipponensis n. sp. ?	Suruga Bay	Nagato
Halimus kyusyuensis n. sp.	Tanegasima Isl.	—
Hephthalpelta aurita RATHBUN	Omae-zaki	—
Krausia laevis n. sp. ?	—	Simane-ken
Lambrus (Parthenopoides) pteromerus ORTMANN	Inuboe-zaki	—
Latreillia phalangium DE HAAN	Siwoya-zaki	Aomori-ken
Leptopenaeus kyusyuensis n. sp.	Bungo Strait	Gotô Isls.
Lyreidus polytus PARISI	Sagami Bay	—
Macrocheira chaempferi DE HAAN	Ibaragi-ken	—
Maja japonica n. sp.	Mie-ken	Gotô Isls.

TABLE IV. *(Continued)*

Species	Northern limit of distribution	
	East or Pacific side	West or continental side
Mixtopagurus jeffreysii (MIERS)	Sagami Bay	Oki Isls.
Mixtopagurus rigidus n. sp.	Omae-zaki	Kosiki Isls.
Munida brevirostris n. sp.	—	Gotô Isls.
Nephrops japonica TAPP. CANÈTRI	Tokyo Bay	—
Nika kotiensis n. sp.	Muroto-zaki	—
Ommatocarcinus fibriophthalmus n. sp.?	—	Tusima Isl.
Ommatocarcinus sp.	Kii Strait	Kosiki Isls.
Paguristes digitalis STIMPSON ?	Siriya-zaki	Tugaru Strait
Paguristes palithophilus ORTMANN	Sagami Bay	Tusima Isl.
Palicus kyusyuensis n. sp.	—	Kosiki Isls.
Paramithrax bifidus ORTMANN	Tokyo Bay	Tusima Isl.
Paramithrax edwardsi DE HAAN	Sagami Bay	Niigata-ken
Parapandalus spinipes grandis (DOFL.)	Sagami Bay	—
Parapleisticantha japonica n. sp.	Omae-zaki	Gotô Isls.
Pilumnoplax glaberrima ORTMANN	Suruga Bay	Oga
Pilumnoplax inaequalis n. sp.	Inuboe-zaki	Gotô Isls.
Pilumnus major ORTMANN ?	Tokyo Bay	—
Pinnotheres pholadis DE HAAN ?	Tokyo Bay	Tugaru Strait
Pleisticanthoides nipponensis n. sp. ?	Inuboe-zaki	—
Plesionika hypanodon DOFLEIN	Sagami Bay	—
Polycheles amemiyai n. sp.	Bungo Strait	—
Praebebalia longidactyla n. sp.	Suruga Bay	Gotô Isls.
Prionocrangon dofleini BALSS	Sagami Bay	—
Pseudocollodes demani BALSS ?	Inuboe-zaki	—
Pugettia elongata n. sp.	Omae-zaki	—
Pugettia incisa (DE HAAN)	Kinkazan	Tugaru Strait
Pugettia minor ORTMANN ?	Siriya-zaki	Hukui-ken
Pugettia nipponensis RATHBUN	Sagami Bay	—
Randallia japonica n. sp.	Suruga Bay	Tusima Isl.
Retropluma denticulata RATHBUN	Suruga Bay	Oki Isls.
Scyra tuberculata n. sp.	—	Kosiki Isls.
Sergestes prehensilis BATE	Sagami Bay	—
Sicyonia cristata DE HAAN	Sagami Bay	Nagasaki
Sicyonia curvirostris BALSS	Simoda	Gotô Isls.
Sicyonia lancifer japonica BALSS	Sagami Bay	—
Speocarcinus laevimarginatus n. sp.	Kagosima	—
Tymolus japonicus STIMPSON	Todo-saki	Tugaru Strait

TABLE IV. *(Continued)*

Species	Northern limit of distribution	
	East or Pacific side	West or continental side
Upogebia kyusyuensis n. sp.	Miyazaki-ken	Gotô Isls.
Urocaris longipes STIMPSON	Kii Strait	—
Uroptychus grandirostris n. sp.	Siwo-misaki	Gotô Isls.
Uroptychus latirostris n. sp.	Bungo Strait	—
Uroptychus scandens BENEDICT	Bôsyû	—

From the above four tables it is clear that the northwards distributing species were collected more frequently from the west side than from the east side of Japan, and in the same time the southwards distributing species stand exactly in contrary. But considering the northern half of Honsyû, the southwards distributing species occur more frequently in the west side than in the east side, that is, we may say that in the west side the distributions of the two categories are not so distinctly separated as in the east side.

The southwards distributing species such as *Ceratopenaeus dalei, Dorippe granulata, Portunus corrugatus strigilis, Neptunus trituberculatus, Pilumnus hirsutus* and *Carcinoplax longimanus* are found northwards till Tugaru Strait, but they rarely occur north of Kinkazan in the east side. Other species, such as *Erithropenaeus akayebi, Axius habereri, Callianassa subterranea japonica, Galathea pubescens, Dromia pseudogibbosa, Tymolus japonicus, Ebalia japonica* and *Pugettia incisa* are supposed to be southwards distributing species, and similarly occur in Tugaru Strait, but not in Siriya-zaki on the Pacific coast. These peculiarities of the distributions coincide with the course of the warm current around Japan.

It is commonly known that the warm current or "Kuro-siwo" running along the Loo-choo Islands sweeps the south-east coast of Kyûsyû, Sikoku and Honsyû and turns eastwards at somewhere near the east of Kinkazan; another current, which branches from the said main current at the south of Kagosima-ken, sweeps the west coasts of Kyûsyû and Honsyû and extends to Tugaru Strait running through the strait between the Isls. of Iki and Tusima. Its small branching current is believed to reach farther west of Hokkaidô. *Trachypenaeus curvirostris* is distributed to the west of Hokkaidô,

and *Penaeus japonicus* is found in a fully grown stage in Mutu Bay.

On the Pacific side, Kinkazan and its neighbourhood seem to be the first southern or the northern limit of the distributions of the northwards or the southwards distributed species respectively. *Chionecetes opilio, Spirontocaris mororani, Spirontocaris leptognatha, Oregonia mutsuensis, Spirontocaris spathulirostris, Crangon trigonorostris* and *Crangon nipponensis* are the representative species belonging to the group which distributes northwards from the said position, and *Paracrangon echinata* seems also to belong to this group, as the occurence in Sagami Bay of this species is doubtful. *Ceratopenaeus dalei, Trachypenaeus curvirostris, Leptocheira gracilis, Pagurus arrosor, Tymolus uncifer, Neptunus trituberculatus* as well as *Cervimunida princeps, Axius habereri, Eupagurus conformis, Eupagurus similis, Catapagurus doederleini, Latreillia phalangium, Tymolus japonicus* and *Ebalia japonica* are southwards distributing species and the neighbourhood of Kinkazan shows the northern limit of their distribution.

In the second, Sagami Bay including Inuboe-zaki plays the important rôle for the distribution. Among the northwards distributing species, *Eupagurus ochotensis, Eupagurus trigonocheirus, Oregonia gracilis, Doclea bidentata, Spirontocaris gracilirostris, Eupagurus anomarus, Eupagurus barbatus, Eupagurus lanuginosus, Scyra compressipes, Chorilia longipes japonica* and *Gomeza distincta* are those, which have their southern limit of distribution on Inuboe-zaki or Sagami Bay. In the southwards distributing species many have their northern limit in this region, as seen in the above tables.

Then comes the third boundary of the distribution in the neighbourhood of Siwo-misaki, including Kii Strait and east of Mieken. *Spirontocaris camtschatica, Spirontocaris geniculata* are found north of the boundary among northwards distributing species, while *Penaeopsis ensis, Plesionika binoculus, Dynomene hispida, Pariphiculus agariciferus, Actaea affinis, Lophoxanthus scaberrimus, Oplophorus gracilirostris, Porcellana picta, Raninoides personatus, Xanthias lamarckii, X. tuberculidens, Ceratoplax ciliata, Erithropenaeus akayebi, Er. acclivis* and *Urocaris longipes* etc. among southwards distributing species have there the northern limit of their distribution.

The last region occupies the area which lies south of Sikoku and Kyûsyû, including Bungo Strait. *Orephorus rugosus, Heteropanope*

glabra, *Alpheus gracilipes*, *Petrolisthes militaris*, *Leucosia haematosticta*, *Ovalipes irridescens*, *Typhrocarcinops ocularia*, *Leptopenaeus kyusyuensis*, *Polycheles amemiyai*, *Uroptychus latirostris*, *Ebalia sikokuensis*, *Achaeus robustus* and *Speocarcinus laevimarginatus* are the species, which do not distribute northwards from this regions. The northwards distributing species, such as *Crangon abyssorum*, *Galathea integra*, *Pugettia quadridens* and *Podocatactes hamifer* are found northwards from this region, but they seem to me to be rather extraordinary.

The cold current or "Oya Siwo", which is supposed to be in intimate relation to the distribution of the northwards distributing species, running down southwards along the Kuril Islands and the east coast of Hokkaidô reaches Kinkazan or sometimes Inuboe-zaki. The influence of this cold current is scarcely noticeable in the south of this region.

On the west or continental side, the distribution of the southwards distributing species seem to be rather simple, as described above. Quite many of the species, however, are not distributed so far northwards from the neighbourhood of Gotô Islands. The following species belong to this group: *Actaea pilosa*, *A. rüppelli*, *A. savignyi pura*, *A. setifer*, *Alpheus gracilipes*, *A. ventrosus*, *Ceratopenaeus mogiensis*, *Charybdis miles*, *Charybdis* (*Goniohellenus*) *subornata*, *Ethusa sexdentata*, *Eumunida smithii*, *Galathea australiensis*, *Galathea latirostris*, *Latreillia valida*, *Lophoxanthus scaberrimus*, *Maja miersi*, *Munida scabra*, *Mursia armata*, *Neptunus pelagicus*, *Nept.* (*Hellenus*) *hastatoides*, *Nika edulis*, *Ovalipes iridescens*, *Pagurus impressus*, *Palicus oahuensis*, *Pleisticantha moseleyi*, *Plesionika martia*, *Achaeus japonicus*, *A. spinosus*, *A. stenorhyncus*, *Axius* (*Eiconaxius*) *farreae*, *A. habereri*, *A. soyoi*, *Cancer tumifrons*, *Catapagurus japonicus*, *Cryptodromia ihlei*, *Cyrtomaia septenspinosa*, *Ebalia rugosa*, *Ebalia scabriscula*, *Ebalia tuberculata*, *Erithropenaeus acclivis*, *Leptopenaeus kyusyuensis*, *Maja japonica*, *Mixtopagurus rigidus*, *Munida brevirostris*, *Ommatocarcinus fibriophthalmus*, *O. sp.*, *Paguristes palithophilus*, *Palicus kyusyuensis*, *Paramithrax bifidus*, *Parapleisticantha japonica*, *Pilumnoplax inaequalis*, *Praebebalia longidactyla*, *Randallia japonica*, *Scyra tuberculata*, *Sicyonia curvirostris*, *Upogebia kyusyuensis* and *Uroptychus latirostris* etc.

On the other hand concerning the northwards distributing species, it seems to be rather complicated. For instance, *Pandalus*

platyceros, *Pandalus hypsinotus*, *Eupagurus ochotensis*, *E. constans*, are distributed so far south as to Nagasaki, yet examining the distributions of these species, they are distributed not so far southwards as in the southwestern part of Japan Sea, leaving some gap along the southwestern part of Honsyû and the north side of Kyûsyû. On the other hand *Pandalus hypsinotus* is known from Tusima Isl., and now it may be presumable that the cold current sweeping southwards along the east coast of Corea Strait and conveys with it these species so much southwards. Similarly, the main cold current coming from Amur coast and sweeping the east coast of Corea dispatches one or more branches towards the east on the way before getting to the Corea Strait. The said branch or branches cross the Japan Sea and get access to the coast of Honsyû conveying cold water froms.

Toyama Bay and its neighbourhood are rich in fauna of the northwards distributing Decapods: *Pandalus platyceros*, *P. hypsinotus*, *Spirontocaris groenlandica*, *Nectocrangon lar*, *Eupagurus ochotensis*, *Spirontocaris biunguis*, *Pandalus borealis*, *Crangon communis*, *Spirontocaris minuta*, *Eupagurus anomarus*, *Nectocrangon toyamaensis*, *N. sadoensis* and *Sclerocrangon gasuyebi* are members of the fauna.

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Genetical Studies on Sesamum indicum, L.

By

Sigeroku Nohara.

With Plates I–X and fifteen Figures in the Text.

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[Jour. Coll. Agric., Vol. XII, No. 2, 1933]

I. Introduction.

Since the rediscovery of MENDEL'S principle of heredity many investigators have devoted much of their time to the experimental studies of heredity in plants and animals and in the course of time the methods of investigation have gradually become accurate and intrinsic or they have advanced from descriptive to analytical and from qualitative to quantitative.

As the results of using these modern methods the solution of nature of heredity gained a step further and grasped a faster foothold than before, such as the wrinkledness and roundness of peas are now known to be due to the difference of a degree of inversion of sugar into starch grains during the maturation of seeds and not the nature of the seed-coat itself, as has once been superficially supposed (DARBISHIRE, 1908), or such as the appearance of anthocyanin pigment is now suggested to be due to the coexistence of flavon and something other to cause reduction of oxygen instead of chromogen and its oxydizing enzyme (SHIBATA, 1915).

Moreover, recently many investigators have become to seek to find the relationships between characters and genes and in turn between the genes and the bearers of them, the chromosomes.

It is now desirous to have investigations to be done in analytical methods and to penetrate into the fundamental nature of hereditary characters as far as possible as DARBISHIRE (1911) states in his book: "The object of our inquiries is not merely to analyze an organism into its component character and to leave the matter there, but to push deeper and obtain some insight into the fundamental nature of these characters". Keeping the principle of investigations in mind I have made the genetical studies on the plant, *Sesamum indicum*, L.

II. Materials.

Sesamum indicum, L. is quite commonly cultivated and it comprises at least three forms. The most distinctive characters of these forms are the colors of the seed-coat as they are named the black sesame, the white sesame and the brown sesame. I used these three forms for the present investigations and now, before going to mention their characters more fully, I may be allowed to make a digression,

in passing, to mention the history and to make the descriptions of the characters of the species hitherto observed.

According to ENGLER and PRANTL (1895) the genus *Sesamum* comprises more than a dozen species, and they are divided into three sections, the most commonly cultivated species being *Sesamum indicum*, L. The species comprises several cultivated forms, and the history of cultivation is very old, being already known among the Greeks and the Romans, but the native home is not exactly known.

In his Landwirtschaftliche Samenkunde, WITTMACK (1922) gives a description of the origin and characteristics etc. of the species the main part of which is as follows:

> *Sesamum indicum*, L. Samen. Kapsel vierkantig, vierfächerig, zweiklappig. *Samen ziemlich flach, im Umriss länglich-eiförmig, hellgelb bis schwarz. Ein sehr* gutes, Olivenöl ähnliches Speiseöl liefernd; 3 bis 3,8 mm lang, 1,8 bis 2,1 mm breit, 0,9 bis 1 mm dick, auf den beiden Schmalseiten mit einem kurzen, auf der einen Breitseite mit einem langen Längsstreifen. Nabelgegend vorstehend, zweikantig, dunkler. Vaterland unbekannt, wahrscheinlich Ostindien, jetzt fast in allen Tropen gebaut. Interessant sind die Oberhautzellen der zarten Samenschale, die jede eine Druse von Kalkoxalat enthalten und dadurch gewiss widerstandsfähiger werden.

The above mentioned WITTMACK'S description is not accurate, but it gives us an outline about the characters and the origin of the plant.

DE CANDOLLE (1889) describes in his book two races of this species, the one having black seeds and the other white, and he adds that the difference in the color of the seeds is very ancient, but he does not allude to the race having brown seeds. Whether or not he was aware of the existence of the brown seeded race, or since his time the race appeared is not known, but the race would have been cultivated somewhere even in his time. According to him the native place of the species seems to have been in the Sunda Isles and it was introduced into India and the Euphrates valley two or three thousand years ago, and also into Egypt at a less remote epoch.

In Sômoku-dzusetsu (IINUMA, 1912) we find a short account about the species in which the above mentioned three forms and a smaller seeded one called "Sizumi" are comprised. The last one is noted in that book to be produced in the province of Satsuma. The first three forms are distinguished mainly by the colors of the seed-coat and the above mentioned Sizumi is distinguished by the smaller size of the seed and the deeper black color of the seed-coat, more-

over by its peculiar character of sinking when the seeds are put in water, hence the name Sizumi which means sinking. Although the descriptions are not exact, yet we are able to identify the first three forms to be so called black sesame, white sesame and brown sesame as we call them today, but the existence of the fourth is very doubtful.

We have so far failed to confirm the existence of the form Sizumi in the Province of Satsuma or anywhere in Japan. I suppose that the so called Sizumi may have been a form yielding comparatively smaller black seeds which appeared once as a fluctuation, and lately disappeared.

As a whole all the descriptions about them in that book are very vague and the characters described in it are found in some points to be different from those of my observations of which will be stated more fully later on.

The noted FRUWIRTH'S book (1912) comprises somewhat detailed accounts of the plant written by HOWARD. As the descriptions are based on the nature of the plant growing in the warmer region as India there is some difference in the blooming time, growth period etc. in comparison with those of the plants growing in a temperate region as the middle part of Japan where I made the observations on the same characters. The fundamental color of the seed-coat is not mentioned in that book, but suggesting the existence of black, white and brown color, he adds the black and whitish seeds and dark brown connected with smoky grey.

In the memoirs of the Department of Agriculture in India A. HOWARD, G. L. C. HOWARD and A. R. KHAN (1919) give nearly the same accounts on the plant as those of the above mentioned FRUWIRTH'S book. BAILEY (1925) comprises in his book a short account of the plant written by W. MILLER. The writer adds to the short description of the plant as follows: "White- and black-seeded varieties have been known for at least two centuries. Runs wild in the extreme South".

Reviewing all the above mentioned descriptions we know that the colors of the seed-coat are conspicuous characteristics and there are three fundamental ones, i.e., black, white and brown. They are, therefore, taken as the distinguishing marks of the species in general.

The origin of these forms is very old but about the age of

the first appearance is not known exactly. The native home of the plant is not known, but there is no doubt that the plant had originated in the tropical region perhaps in East India or Sunda Isles from which it spread over the tropical as well as the subtropical region or even to the temperate countries as China or Japan etc.

I have designated, the white-seeded form as I-type, the black-seeded form as II-type and the brown-seeded one as III-type for the sake of convenience throughout the present investigation. Although we are able to know the outline of the characters of these three forms by the descriptions of the above mentioned several writers, yet it will be necessary to note briefly what are the main characteristics of my materials.

I-type. Stem normal, branching, with comparatively long hairs. Leaves oblong or lanceolate, but the lower ones are broader and often 3-lobed or parted. Flowers, one on each axil and on both sides nectar glands produce. Corolla somewhat labiate in shape, outside of the upper lips pale rose and open wide usually reflexed. Stamens didynamous. Ovary 2-celled. Seeds comparatively small, white, surface smooth (Pl. I, Fig. 1; Pl. II, Fig. 4).

II-type. Stem normal or fasciated with short hairs, not branching. Leaves lanceolate or oblong, and not parted. Flowers solitary in the axils and the nectar glands on each side of the flowers as I-type. Corolla somewhat labiate but less pronounced and it usually does not open wide. The outside of the upper lips of the corolla is slightly tinged or almost white and the inside of the flower lips is almost white or has no patch of purple dots. Ovary more than three cells. Seeds black, large, surface coarse (Pl. I, Fig. 2; Pl. II, Fig. 5; Text-fig. 1).

III-type. Stem normal with short hairs, branching habit less conspicuous. Leaves similar to those of II-type. Flowers three on an axil and no nectar glands. Corolla almost similar to that of II-type with an exception of deeper color of the outside of the upper lips and of having purple patches in the inside of the lower lips. Ovary 2-celled. Seeds not smaller than those of I-type, brown, less smooth (Pl. I, Fig. 3; Pl. II, Fig. 6).

As will be mentioned later, I began my experiments with these original three types, I, II and III, but after some generations secondary or tertiary and more lines descending from the original stocks

were cultivated in parallel and they were used in the experiments as the second series or the third ones etc. respectively, of course the original stocks being the first.

The secondary or tertiary line etc. descended from one stock of a pure line could be regarded as pure as the stock in all characters excepting the cases where possibly an alteration of factor or factors (gene or genes) occur through mutation or in some other cause as that of fasciation of the stems of which will be discussed more fully later.

Extra II-type or early ripening form. In the course of my experiments this form was added and as it yields black seeds it may be called extra II-type. The seeds of this form were sent by Mr. HATAKOSHI of the Agricultural Experiment Station of Ibarakiken in 1928 and since then the form has been used in my experiments. The pedigree test of this form has been performed and the characters so far obtained are as follows:

The plant has short hairs and the stem has unbranched habit like II-type, but the latter habit may not be so definite as the hair is, as will be discussed later on. The stem nature as to fasciation is like that of II-type. Flower is comparatively larger than that of II-type and it opens as wide as that of I-type and the upper side of the corolla has deeper rose color unlike II-type.

The leaves are simple like those of II-type. Flowers solitary on an axil and two nectar glands are produced on its both sides as in I- and II-type. Capsules are many celled like those of II-type and the seed color is black like that of I-type too, on account of which this form really belongs to the II-type.

The flowering time and the ripening of seeds are earlier than those of the other forms.

For the genetical studies the materials to be used are not restricted necessarily to pure lines of the materials, but using one of the pure lines about the characters to be treated facilitates the experiment, so such materials of pure line are very often chosen at the beginning of the work. Then the necessity of testing pure lines would come at the start.

I tested the plants for their genetical constitutions through the growing the seeds obtained by self-fertilization on the one hand and by crossing on the other for at least 10 years excepting the so called "Early ripening" and did not see any other different nature excepting only some fluctuating variations, so I could say with much confidence that I had started with homozygous plants as far as the characters in question are concerned.

III. Methods of Investigations.

As the plant is an annual it necessitates us to sow the seeds every year in order to obtain the individuals, so that we cannot trace up some characters, if wanted, in the same individuals after that year. This is an unfavorable quality to geneticists, but cultivation of the plant is not difficult and an individual plant usually yields abundant seeds at a time. This is a favorable quality to geneticists.

The flower of the plants is entomophilous and some insects belonging to *Hymenoptera* are noticed most frequently to visit the flowers, but sometimes some member of *Lepidoptera* as *Parnara* is also noticed to come. They usually come to the flowers at about 10 o'clock till noon on a clear day and the smaller members of *Hymenoptera* creep into the flower tubes and suck up the nectar and on this occasion they effect the pollination, while the larger members of *Hymenoptera* can not creep in the flower tubes but they pierce the upper part of the flower base and succeed in sucking.

The stigmas are parted into two lobes and usually they adhere with each other, but at a slight touching they open abruptly and can receive the pollen grains in the case when the latter are carried by insects. The device of catching the pollen grains of the flowers, therefore, is reverse to that of *Mazus Miquelii*, MAK. whose stigma closes its fork shaped parts suddenly when such things as insects touch. The flowers open usually early in the morning, almost regularly two flowers a day, when the floral axis is normally developed, and the castration is operated one day previous to the opening. To protect the flowers paper bags were used as usual and even when self-pollination is desired, artificial aids have been given to ensure the pollination. When fertilization is effected the stigmas shrivel and the styles fall off the next day.

Labelling methods seem to be a trifling matter but following a systematized way is necessary in order to carry on the work smoothly, and especially so when a number of generations is increasing with the same materials. For this purpose I adopted the system of using the exponents of powers to denote the self-fertilization. Thus II^2-A denotes one plant (say A) among those ones raised from a self-fertilized II-type of some plant strain, and II^2-A^2-M denotes the plant (say M) among the population raised from self-fertilized seeds of such A-plant of the previous generation. Again (II^2-A^2-M) × (II^2-A^2-N) denotes a plant derived from the cross-fer-

tilized seeds between such M-plant mentioned above and its fraternal N-plant. Sometimes the exponents might be omitted and when we have many individuals at one generation, numerals are used instead of letters as WHITE (1917) did in the Brooklyn Botanic Garden.

According to the "Presence and Absence" hypothesis of BATESON a small letter of factorial composition was supposed to designate the real absence of the corresponding gene or factor denoted by the large letter, but throughout the present work I am going to follow MORGAN who maintains that both of the allelomorphic genes or factors are supposed to be present.

The notation of factorial composition, however, is different from that of MORGAN, i. e., a large symbolic letter, of course following mnemonic system is derived from the dominant character because this does not only follow the pioneer's fashion, but also there is not much confusion found in usual cases excepting such a *Drosophila* case which has so many recessive or mutant genes vs. only one dominant eye color (MORGAN, 1919); moreover even when we have one recessive gene and several other dominant genes against it, it would be difficult to tell for which one the large letter stands, as in the case of combs of fowls (BATESON, 1913).

The experiments of hybridization were carried on repeatedly during those 21 years from 1912 until 1932 and as to the results of the experiments between I- and II-type, those obtained from 1921 to 1923 are taken into consideration as the first series and those obtained from 1923 to 1925 as the second series and those obtained from 1924 to 1926 as the third series and again those obtained from 1928 to 1929 as the fourth series of the hybrids.

As has already been stated, the predecessors of each series came forth from a common stock which had been tested to be of a pure line for the characters in question, so that the descendants should behave in the same nature and give the same results, provided they are treated in the same way and would not have caused any internal change or mutation.

Other experiments than those of the above mentioned series have been carried on between those three types during those 21 years, and the experiments by back-crossing have also been carried on comparatively in later years although the results are not mentioned in the chronological order.

IV. Fasciation of the Stem.

Banding or expanding of organs such as stems or inflorescences or receptacles etc. seems to be the results either of "fusion" of the like organs or parts, or of inclination of "division" of that

Text-fig. 1. Upper part of fasciated plant of II-type.

part. WORSDELL (1916) making a distinction between these two cases, called the banding as "fasciation" if such a phenomenon is due to the division of that part, otherwise "synanthy."

Following this definition the banding stem of *Sesamum indicum* is a fasciation. This phenomenon has never been observed in either I-type or III-type while it is observed very often in II-type, so that the fasciating nature is heritable in this plant as the same phenomenon is heritable in some forms of *Pharbitis Nil*, *Celosia cristata* and many other plants.

Thus among the plants of II-type fasciation is not only observable but also non-fasciated plants or normal stemmed ones are to be seen mixing together, but this distinction between them is a matter of consideration, for the fasciation displays its habit well when the stem has attained its maturity, although it can sometimes be recognized when the plants are as yet young. Moreover, there are great diversities in degrees of fasciation, and if the stem is slightly fasciated it is apt to be mistaken as normal. Thus this phenomenon makes the genetical analysis difficult on which more fully will be discussed later on.

I used I- and III-type for normal plant and II-type for fasciating one as the materials of the investigation chiefly, but from the fasciated II-type normal stemmed strain comes out and for the investigation of this character the latter one is sometimes used.

The habit of fasciation seems to associate with that of multilocular ovaries.

A. FIRST SERIES OF I- AND II-TYPE.

F_1-GENERATION. Since the beginning of this experiment innumerable individuals of F_1-generation, produced by crossing between plants of I-type which have always normal stem or inflorescence and fasciated plants as well as normal one of II-type, have been raised and in examining them, in their full growth, I never saw any fasciated individuals among them.

From the results we can certainly conclude that the normal stem or inflorescence is completely dominant over the fasciated one, either in direct or in reciprocal crossing, although the reappearance of normal stem or inflorescence from seeds obtained by self-fertilization of the fasciated plants is not uncommom. The fact of

the reappearance of dominant characters in the offspring from self-fertilized recessive organisms is not quite rare but this phenomenon is usually to be thought as a curious matter, and for the interpretation of the phenomenon my idea will be given later on.

As will be enumerated later some investigators inform the F_1-plant is intermediate in respect to the character in question, but this expression is, in my opinion, not correct because the expression means degrees.

The problem to be considered now is fasciated or not and not the degrees of fasciation. Even the expression might be sanctioned yet it is very difficult to determine whether the character is really intermediate or not as the display of the character fluctuates in a wide range according to environmental conditions, at least in the case of fasciation.

Then it is hoped to express the character as incomplete dominant even in such cases as in color of *Mirabilis jalapa alba rosea* or half-dwarf *Pisum* (BATESON, l. c.). Such things do not have much weight on the subject and I have only taken this occasion to call attention to the use of the terms.

From these considerations I have expressed the character in an alternate way, i.e., fasciated or not in describing it and as to the degrees of fasciation I mean to consider in another place.

F_2-GENERATION. In this generation there appeared those individuals having a normal stem or inflorescence and those having a fasciated one so that a segregation[1] of the character is evident, but the numerical ratio in later generations has been found to be somewhat irregular for Mendelian system.

The individuals of this generation in this series were 41 in number and among them there were 39 normal and 2 fasciated plants.[2] If we assume them to have segregated into dominants and recessives in the ratio of 15:1 respectively the deviation of the observed individuals from the expected ones is ± 0.22 and the mean error is ± 0.60; or if we assume them to have segregated in

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1) The term "segregation" will be an appropriate use for the departure of genes as MORGAN (1919) writes but some investigators use it for the departure of characters. Here I use the term in two ways and what is meant can easily be understood by the context.

2) Pedigree Nos. are 12 and 38.

the ratio 3 : 1 the deviation is ±0.80 and the mean error is ±0.27 (JOHANNSEN, 1913)[1].

Of these two assumptions the former fits better than the latter does, because in that case the deviation is much smaller than the mean error while in the other it is reverse, so that the segregation of the characters seems to have been performed in the ratio of 15 : 1 following the Mendelian system and we know, in turn in this case, that the character in question is displayed by two-gene difference.

When we designate the two pairs of the genes concerning the character as N_1 vs. n_1 and N_2 vs. n_2, then the plants of I-type have the genetic constitution of "$N_1N_1N_2N_2$" and the fasciated plants of II-type in this series have the formula of "$n_1n_1n_2n_2$" and the F_1-plants produced by crossing these two races have a formula of "$N_1n_1N_2n_2$"; the capital letter "N" denoting the gene for normal stem and its small letter "n" for fasciation.

Taking the assumption as granted as true we could formulate the individuals of this generation as shown in Table I in which the numbers in parentheses denote the individuals in every 16 offspring.

TABLE I

Class I	Class II	Class III	Class IV
$N_1N_1N_2N_2$ (1)	$N_1n_1N_2n_2$ (4)	$N_1n_1n_2n_2$ (2)	$n_1n_1n_2n_2$ (1)
$N_1N_1N_2n_2$ (2)		$n_1n_1N_2n_2$ (2)	
$N_1n_1N_2N_2$ (2)			
$N_1N_1n_2n_2$ (1)			
$n_1n_1N_2N_2$ (1)			

Of these four classes I, II and III make the reappearance of normal stem or inflorescence, altogether 15 in number, and the class IV makes the reappearance of fasciated one, 1 in number, in every 16 plants of this generation. As we can not find any difference

1) The mean error in such cases is calculated by the formula $m_E = \sqrt{\frac{N(K-N)}{n}}$, throughout the present work.

among those normal stems or inflorescences in the former three classes, we can infer that only one large N could cause the normality in the stem in the same degrees as four N's or three N's or two N's and conversely we could say that one small n, two small n's and three small n's do not make any difference in effects upon the same form.

From the above mentioned results I am now inclined to conclude that the genes have no cumulative effects on the stem or we might say the case is one of the non-cumulative polymeries. If this be the case the degrees of fasciation do not seem to have any relation with the number of recessive genes, then the degrees of fasciation seems to be due to another cause or causes, that is, in my opinion, to environmental conditions as is already stated.

F_3-GENERATION. Among the 41 individuals of the F_2-generation the 17 progenies (Ped. Nos. 4, 5, 6, 7, 8, 9, 12, 15, 18, 22, 28, 29, 31, 33, 34, 35 and 36) had few or no progeny so that we have now to consider about the progenies of the remaining 24 individuals in the present generation.

The pedigree number 38 which displayed a fasciation in the F_2-generation is included into these 24 individuals and presumably it has $n_1n_1n_2n_2$ for its genetic constitution (Class IV in Table I), so that we might expect it to have exclusively fasciated progenies in the next generation, but in raising its progenies (12 in number) we found contrary to our expectation that there were 2 normals and 10 fasciated plants among them, and about this peculiar phenomenon of the reappearance of the dominant character from recessive one I like to discuss fully later on.

The progenies of these 23 F_2-individuals were 225 in number and in examining them the following results have been obtained. The eleven plants (Ped. Nos. 1, 2, 11, 19, 20, 24, 25, 27, 32, 39, and 40) out of the 23 individuals had their progenies, 92 in number, each having 8 or more, consisted exclusively of normal plants so that these 11 individuals are very likely to belong to the class I of the foregoing assortments shown in Table I.

The remaining 12 individuals of the F_2-generation had 133 progenies and among them the 6 plants (Ped. Nos. 3, 17, 21, 23, 26 and 41) had 95 normal plants and 7 fasciated ones while the 6 others (Ped. Nos. 10, 13, 14, 16, 30 and 37) had 24 normals and 7 fasciateds as the following:

TABLE II

	Ped. Nos. of F_2	Normals	Fasciateds
First group	3	9	1
	17	12	1
	21	20	1
	23	32	2
	26	12	1
	41	10	1
	Total	95	7
Second group	10	3	1
	13	6	2
	14	4	1
	16	4	1
	30	2	1
	37	5	1
	Total	24	7

In Table II the first group belongs perhaps to the class II and the second group to the class III of the assortments shown in Table I, but the numerical ratios of segregation in F_2 and F_3-generations do not agree with the expectation as the numbers of the individuals are too small, however it will be inferred that the segregation of the characters into the normal and the fasciated one has taken place in the ratio of 15:1 in some cases and 3:1 in the others.

B. SECOND SERIES OF I- AND II-TYPE.

F_1-GENERATION. The individuals of this generation produced by the crossing between one of I-type whose stems are always normal and a fasciated one of II-type which usually produce fasciated plants but sometimes produce the plants of normal stem, have all normal stems or inflorescences so that the fasciation is recessive to normal as in the case of the first series.

F_2-GENERATION. I have raised 65 individuals in this generation from the seeds obtained by self-fertilization and among them 53 were normal and the remaining 12 were fasciated so that the segregation of the characters or genes is also obvious.

If we assume them to have segregated into dominants and recessives in the ratio of 15:1 and calculate them we have ± 1.91 for the deviation and ± 0.48 for the mean error. Again, if we assume them to have segregated into 3:1 ratio and calculate we have ± 0.26 for the deviation and ± 0.21 for the mean error. Of these two calculations the assumption of the latter does fit better than the former and the characters can be recognized as segregated after the simple Mendelian ratio, that is in this case the character can be inferred to be displayed by one gene-difference.

If this be the case there will be a question arising why in the first series the fasciation is displayed by two gene-differences while *in the second by one.*

There is nothing to be wondered at, however, when we think that the material of the normal plant in the first series has $N_1N_1N_2N_2$ for its genetical constitution and that in the second has $N_1N_1n_2n_2$ or $n_1n_1N_2N_2$ which always breeds true to the type and corresponds to some of the class I shown before.

If we had happened unconsciously to take such a plant for the material of normal plant in the second series, allelomorphic constitution of the receseive character being $n_1n_1n_2n_2$, the F_1-plants should be normal and their genetic constitution wlll be either $N_1n_1n_2n_2$ or $n_1n_1N_2n_2$ according to the genetical constitution of the normal parent, and in either case the F_2-generation is expected to come forth in the ratio of 3:1 which is actually realized.

F_3-GENERATION. I have raised the progenies of all the individuals as in the F_2-generation by self-fertilization and obtained 517 individuals in all. In examining them I found that 2 of the 12 fasciated F_2-plants, i. e., Nos. 21 and 27, have segregated into normals and fasciateds. The former had 4 normals and 1 fasciated and the latter had 3 normals and 1 fasciated, both making the ratio of nearly 3:1, as some of the fasciated plants had produced two types in F_3-generation in the first series, though the ratio is not necessarily always the same.

Among the 53 normal plants of F_2-generation 10[1] were proved to be the heterozygous ones judged by their progenies and the total sum of the progenies were 80; 66 being normals and 14 fasciateds.

When we assume these 10 individuals of F_2-generation to have

1) The pedigree Nos. are 8, 28, 30, 44, 46, 49, 50, 58, 64 and 65.

segregated into normals and fasciateds in the ratio of 3 : 1 respectively as will be expected to be and calculate the progenies, 66 dominants to 14 recessives, we have ± 0.30 for the deviation and ± 0.19 for the mean error.

The results of the above mentioned calculation show that the deviation is less than twice the mean error and if we take of some individuals which would have been the excess from the dominants the ratio would become better fitted than we actually see, so that the assumption of segregation may very likely be true, and in turn we may infer that the 10 heterozygous indviduals of the second generation have the formula of $N_1n_1n_2n_2$ or $n_1n_1N_2n_2$ for genetic constitution.

If we arrange the normal individuals of the F_2-generation according to their progenies or F_3-individuals we have 43 homozygous normals to 10 heterozygous ones while we expect this ratio to be 1 : 2 respectively.

The disagreement of the observed ratio with the expectation or a great excess of homozygous normals against heterozygous ones which has been always the case will be discussed with the above mentioned peculiar phenomenon of production of dominants from recessives later on.

C. BACK-CROSSINGS.

In the years 1928, 1929 and 1931 I made back-crossings between one of the F_1-individuals of the second series and one of the II-type. In this case let us suppose the F_1-plant as having $N_1n_1n_2n_2$ for its constitution and the one of the fasciated plants of II-type as having $n_1n_1n_2n_2$ as before, as it is indifferent to take $n_1n_1N_2n_2$ for the F_1-plant. Then in this case we are dealing with a back-crossing of monohybrids, i. e., $N_1n_1 \times n_1n_1$ and the following results were obtained:

TABLE III

Characters		Hairs		Branches		Stems		Leaves		Flowers		Ovary-cells	
Years	Individuals	L	S	B	U	N	F	S	C	O	C	2	∞
1928	72	35	37	24	48	52	20	71	1	32	40	29	43
1929	63	37	26	43	20	43	20	54	9	53	10	32	31
1931	170	81	89	72	98	107	63			54	116	85	85
Total	305	153	152	139	166	202	103	125	10	139	165	146	159

The table contains other data than the datum which concerns the character under the present consideration, but this will be utilized in further considerations of the other data whenever they may be required, and as we see in the table, L and S under the heading of Hairs stand for long (really intermediate in degrees in this case) and short hairs respectively; B and U under the heading of Branches stand for branched and unbranched respectively; N and F under the heading of Stems stand for normal and fasciated stems respectively; S and C under the heading of Leaves stand for simple and compound leaves respectively; O and C under the heading of Flowers stand for open and closed flowers respectively; 2 and ∞ under the heading of Ovary-cells stand for 2-celled and many-celled ovaries respectively.

Turning now to the consideration of stems we see in the table that normals are 202 while fasciateds are 103 in number. Obviously there is too great a difference from the expectation. This will be due to the errors caused by the same reason as those in the F_2 and those subsequent generations mentioned before, so that this will be discussed later on.

D. Conclusion.

1. The habit of fasciation in II-type of *Sesamum indicum* is heritable and the results of experiments with I-type which always show normal character reveal that normal is dominant over fasciation.

2. The character of fasciation of the first series in my materials is proved to be displayed by two-gene difference in non-cumulative way so that in F_2-generation the normal and the fasciated plants come out in the ratio of 15:1 respectively, and in the subsequent generations heterozygous individuals segregate into two types in the ratio either of 15:1 or 3:1 according to the genetical constitutions of their parents.

3. In the second series the character is proved to be displayed by one-gene difference so that in the F_2-generation the normal and the fasciated individuals come out in the ratio of 3:1.

4. The character of fasciation, however, seems to be unstable which means the alteration of genetic constitution, and sometimes this character is so little developed that it escapes our keen eyes

even when the plant has its constitution to be fasciated. These might be the causes of inconformities between the theoretical and the expected ratios. In such cases the normal is always in excess to the fasciation as far as my experiments are concerned.

E. DISCUSSION.

Now before going to discuss the above mentioned conclusions let us consider in detail to some extent the inheritance of fasciation in general as this phenomenon has been an important subject of investigation from the view point of plant biology.

MIYOSHI (1931) states in his book several instances of this phenomenon, but he does not allude to the genetical nature excepting YAMAGUCHI'S experiments which will be fully alluded to later on. DE VRIES (1906) enumerated in his book *Primula japonica, Ranunculus bulbosus* and ten others as examples among his observations and he classified these types into two groups, one of which is poor race and the other rich, respecting the hereditary nature. WHITE (1916) was able to find the record of fasciation in 102 families out of 290 of vascular plants, and even now we could also give a long list of fasciated plants, but there will be no need in doing so.

Thus in spite of the common occurrence of the phenomenon yet very little has been done on genetical investigation until recently; however, we have now some informations of the results of genetical investigation obtained by several experimenters. The results of the investigations so far obtained are as follows.

It is a well known fact that one who took the lead of genetical investigation on this phenomenon is MENDEL (1865). He experimented with edible peas and the results indicate that normal is dominant over fasciation, and in F_2 and subsequent generations the hybrids segregated into normals and fasciateds in an approximate ratio of 3:1 respectively, so that the character is known to have been displayed by one-gene difference.

LOCK experimented on the behavior of the phenomenon with the same plant and he confirmed MENDEL'S results but he noticed various degrees of fasciation in the segregation of the character (DE VRIES 1906). BATESON and PUNNETT note they have experienced the occurrence of various intermediates in F_2-generation with the same plant (BATESON, 1913). WHITE (1917) confirmed the complete

dominancy of normal stem over fasciated one and he interprets this to be due to one-gene difference.

All the above mentioned experiments with peas tend to agree in their results, i. e., the character in question is hereditary and it is displayed by the difference of one or at most a few genes and it segregates after a simple Mendelian rule, but fasciation in peas and in other plants may not necessarily be said to be always in hereditary nature.

WHITE (1914) also experimented on the behavior of fasciation in tobacco plant and he found that the F_1-plant is intermediate and that in F_2-generation the segregation into normal, intermediate and abnormal is in an approximate ratio of 1:2:1 respectively which clearly shows that only a single gene-difference is involved. KELLY (1927) experimented on the nature of fasciation of *Phlox Drummondii* and his experimental results indicate that in F_1-generation the abnormality of the stem is recessive to normal, and in F_2-generation the heterozygotes segregate in an approximate ratio of 3:1, although it sometimes does not fit well the theoretical expectation. He thinks the deviation to be of significance and seems to attribute this to the high fluctuating nature of the character. Besides the above mentioned investigators STOUT experimented on the same character with *Cichorium Intybus* and BAUR with *Antirrhinum majus*, and the former reports the fasciation is intermediate in F_1-generation, and the latter found the nature to be simple recessive in F_1-generation, but in both cases the nature is found to be very variable.

The results of experiments with *Zea Mays*, however, do not necessarily come to conformity with each other. The results of the experiments obtained by DE VRIES and others, for instance, indicate that the nature of fasciation of corn-ear is inconstant while those of others seem to indicate that the fasciation is dominant over the normal and that in F_2-generation the heterozygous plants segregate after the simple Mendelian ratio; and still the results of others indicate that the fasciation is recessive, i. e., normal is dominant and in F_2-generation the heterozygous ones segregate simply into 3:1 ratio.

I investigated the hereditary behavior of fasciation of *Pharbitis Nil* with the so called variegated Kuzyaku-leaves in 1914. At that time I raised the plants to F_2-generation of hybrids be-

tween a plant of the above mentioned race and one from the other race with normal stem and ordiary green leaves, and I observed that the normal stem is dominant over the fasciated one and the character segregated in F_2-generation, but I did not take the record of the number of the segregated individuals for some reason, so that I did not make it public.

HAGIWARA (1926) reports preliminarily in the Journal of Scientific Agricultural Society, No. 255, that the character of fasciated stem of *Pharbitis Nil* is displayed by the so called Kuzyaku-factor "p" and a fasciation-factor "f'" and he experimented on the hereditary behavior of the same character more extensively, and he came to conclude that the fasciated stem is recessive to normal one following the Mendelian rule and that the character of fasciation is displayed by the cooperation of the gene "f'" for the fasciation proper and the gene "p" for the leaf-shape as he presumed. According to him these genes are sometimes transformed to "F" (normal stem) and "P" (ordinary leaf-shape) respectively, and the occurrence of normal stemmed plants mixed with the fasciated ones in the offspring raised from fasciated plants by self-fertilization is due to the transformation of the gene or the genes.

YAMAGUCHI investigated the same phenomenon quite extensively. He states in his paper that he began his preliminary experiments on genetics with *Pharbitis Nil,* along with the investigation of the causes of fasciation from morphological as well as physiological stand point of view (YAMAGUCHI, 1926-a). He seems to have devoted much of his earlier time to the investigation of causes of the phenomenon and he came to conclude that the phenomenon is due to a mechanical cause as far as his experiments are concerned, but he did not touch the question whether the phenomenon in every case is likewise due to the same cause.

The foregoing YAMAGUCHI'S conclusion as to the cause does not seem to have much bearing upon genetics but by his investigation the phenomenon is, partly at least in certain point, cleared up and it has been shown to be a case of fasciation in WORSDELL'S sense; moreover the inclination of dividing the stem-tip resembles that of my material, *Sesamum indicum,* so that I shall allude to his conclusion here a little more. His conclusion consists of eleven points and among those the most important for the subject seems to be the eleventh which runs as follows: "Auf dem

ausgewachsenen, faszierten Stamme ist eine deutliche Vegetationslinie vorhanden. Sie wird durch die Verwachsung der Blattstiele mit dem Stengel und die Blattvermehrung im frühen Entwicklungsstadium ausgebildet. Die Verwachsung der Blattstiele mit dem Stengel und die Blattvermehrung im frühen Entwicklungsstadium können also als die mechanischen Ursachen der Verbänderung bezeichnet werden."

As he states in his paper the causes of fasciation in general had not been thoroughly investigated although NESTLER and others had carried out several experiments physiologically and morphologically.

Though his material is confined to a single species, *Pharbitis Nil*, YAMAGUCHI threw a light upon the cause of the phenomenon. Later he drew a conclusion from his genetical investigations on the same plant and criticized the HAGIWARA'S conclusion (YAMAGUCHI, 1926-a,-b).

Based on the results of his experiments he presumed two pairs of factors concerning the phenomenon in question, i.e., the one is *F′* vs. *f′* and the other *is* Bs vs. *bs*, and *he thinks the character is* displayed by the co-existence of these two genes (YAMAGUCHI, 1926-a). He thinks, however, the second pair of genes, Bs-bs, might be complementary to the other, F′-f′, or be related with the degree of intensity of fasciation or be related with the cotyledon-petiole. Also he presumes the presence of another pair of genes, P-p, for Kuzyaku-leaf but he does not think the gene to have any part in displaying the phenomenon of fasciation opposed to HAGIWARA'S idea, and he thinks only the gene to have a strong linkage with one of the preceding two genes although he does not determine which pair of fasciation does have the linkage with it.

In one of his experiments, however, YAMAGUCHI obtained the ratio of 63 : 1 and he thinks the genetical composition of stem character will be more complicated than we think. Besides the above mentioned genes he presumed another pair of genes, M-m, for Tatsuta-leaf, but this does not concern us here.

IMAI also experimented extensively on genetical nature of *Pharbitis Nil* and he states his results on this character and criticizes the HAGIWARA'S conclusions. According to him the normal and the fasciated stem of *Pharbitis Nil* is displayed by three-gene difference, the former character being dominant over the latter, and one of these three genes is linked in about 2.5% with another gene

"p", the so called Kuzyaku-leaf.

The extracted fasciated form in F_2- and F_3-generation etc. can not be said to give necessarily the offspring of their parental type; in other words, some normals may come forth from fasciated ones in later generations. In this case the normal ones, according to him, are not really normal but deceiving the normal form, i.e., they have the same genetical composition as that of the pure fasciated ones, but the fasciation is suppressed by a modifier or modifiers to some extent and when the modifier or modifiers work in full measure the power of fasciation is almost entirely suppressed and in this case the plants to be fasciated assume the form of normals which he calls the "false normals" (IMAI, 1926).

Now let us review the results of the above mentioned investigators and consider the character in question of *Sesamum indicum*. Normal stem or inflorescence is dominant over fasciation in *Pisum sativum*, *Phlox Drummondii* and *Antirrhinum majus*, and it is intermediate in *Nicotiana tabacum* and *Cichorium Intybus*. If we take the intermediates into the group of dominant, laying aside the degrees of fasciation, all these examples indicate nearly the same nature concerning the character on the whole, i.e., fasciation is recessive in F_1-generation and it segregates in about 3 : 1 ratio in F_2-generation which reveals that the character is displayed by one-gene difference though there is found a high variability in degrees.

As is stated already in corn-ear the results of some investigators do not show the same nature as to fasciation as the above mentioned results but excepting one case obtained by DE VRIES and others which is inconstant, all the others indicate that the character in question is displayed by one-gene difference and in F_2-generation the heterozygous one segregates simply in about 3 : 1 ratio as usual.

According to the results of HAGIWARA'S, of YAMAGUCHI'S and of IMAI'S exeriments on *Pharbitis Nil* it is clear that the hereditary nature of the character is more complicated than that of the foregoing plants and there seem two or more genes to be concerned in displaying the character.

Then there are two different categories in fasciation of stems or inflorescences in regard to the number of genes in general. The first is a group in which are comprised those plants having a fasciation caused by a pair of genes, and the second is that in which are comprised those plants having a fasciation caused by

two or more pairs of genes. Thus the case of fasciation in the first series of my original stock will be grouped in the second category and that in the second series into the first one.

The cases of the first category are simple for the Mendelian system but in the case of my *Sesamum* one thing should be considered, that is the excess of dominants to recessives when compared with the 3 : 1 ratio, but the question will be considered at the end of the discussion. The cases in the second category are not simple to give appropriate interpretations, i.e., there are disagreements of opinions in regard to the rôle of genes concerned.

Thus HAGIWARA necessitates two recessive genes, f′ and p, in a complementary way to cause the phenomenon, while YAMAGUCHI presumes two pairs of genes for the phenomenon, F′-f′ and Bs-bs, and he seems to think that the appearance of the phenomenon requires these two genes, f′ and bs, to be present, but in his experiments he obtained three different results in ratios, i.e., 15 : 1, 3 : 1, and 63 : 1 at last he declared that the genetic constitution of stems seems to be more complicated than we think. YAMAGUCHI, however, does not conclude what rôle plays each of his assumed two pairs, but he inclines to think that one of them might be concerned to the intensity of fasciation or to the special relation between cotyledon-petiole and stem. Still IMAI presumes three recessive genes, i.e., f^1, f^2 and f^3, for the same phenomenon and seems to deny HAGIWARA'S two-factor presumption on account of the insufficiency of materials.

I can not say anything definitely about the number of genes concerning the phenomenon occurring in *Pharbitis Nil* beside the linkage with other gene or genes, but it is clear that at least two recessive genes are concerned. The definite rôle of each gene, however, seems not to be determined yet.

In the original stock of *Sesamum indicum* the fasciation seems to be caused by two recessive genes, as already stated, and the rôle of each gene is the same neither lessening nor intensifying the degrees of the fasciation so that this is one of the cases treating the duplicate genes, the first one of which was found by NILSSON-EHLE in wheat (NILSSON-EHLE, 1909), and of the capsule form of *Bursa bursa-pastoris* studied by SHULL (1914) and of variegation in *Plantago* investigated by IKENO (1917).

Of these cases the first one is an example of cumulative effect of the color factors while the latter two are the examples of non-

cumulative polymery introduced by JOHANNSEN or homomery by PLATE and the case of fasciation in my *Sesamum* will add one example to the last two.

The appearance of the same fasciation in the second series with one-gene difference instead of two is another evidence of non-cumulative polymery. Such a phenomenon was also found in YAMAGUCHI'S experiments and from the above mentioned consideration his case might be said appropriately to be a case of polymery too.

Next there arises a question as to the degrees of fasciation. Many of the investigators consider the cause or causes of fasciation, but only a few seem to take the distinction between the causes of fasciation and those of degrees of the phenomenon into their consideration.

Thus DE VRIES necessitates the external conditions besides the internal ones for the production of the phenomenon and he enumerates several chief points as following: (a) The stronger plants or branches are more liable to expand or flatten out; (b) plants sown earlier in the year are apt to cause more fasciation; (c) crowding diminishes the proportion of fasciated individuals; (d) numbers of fasciations can be increased by adding manure in proper quantity; (e) by pruning and by selecting, the production of fasciations can be increased to some extent (DE VRIES, 1903). He does not, however, distinguish between the gene which concerns the occurrence of the phenomenon and the one which concerns the degrees of the same.

GOEBEL (1900) states in his book that we can produce fasciation artificially by causing the 'sap' to flow rapidly and intensely, but he does not say anything definitely about the degrees of the phenomenon.

Some other investigators, however, seem to think that there will be an intensifying gene or genes other than that or those concerning fasciation itself. Such as HAGIWARA (1926) considers the degrees to be due to some gene or genes other than the effect of environments but he does not come to decide what such a gene or genes are.

YAMAGUCHI seems to recognize the environmental conditions to affect the degrees of fasciation partly and he thinks that the genes, Bs-bs, might partly be concerned the quantitative difference of the intensity of the phenomenon but he does not decide it (YAMAGUCHI, 1926-a).

Based on my experiments of *Sesamum*, I am inclined to think

that the degrees of fasciation owe chiefly to fluctuations due to environmental conditions which of course are independent of genes causing the fasciation itself just as stem-lengths do among the tall or the short pea-plants although they have nothing to be thought of such intensifying gene or genes. Moreover, the degrees of fasciation should be measured by breadth and it is of a continuous variation so that if it were due to some intensifying genes there should be innumerable ones which concern the degrees, but it can not be thought to be so.

Still there remains a question as to the excess of normal stems to fasciated ones. The occurrence of excess of dominants to recessives or at least the discrepancy between the observed number and the theoretical one in F_2-generation, provided that the segregation was performed after the Mendelian system, has been observed not infrequently. The case of *Portulaca* investigated by BLAKESLEE (1920), that of ears of *Zea Mays* of EMERSON (1914), that of *Celocia cristata* of TERASAWA (1922), that of *Phlox Drummondii* of KELLY (1927), that of *Pharbitis Nil* of HAGIWARA (1926) and others, and the case of my *Sesamum* of which I shall reserve for future discussion are the instances of this sort. Moreover, the production of plants having dominant character from the plants having the recessive one such as *Plantago* of IKENO (1923) may be classified into this group in some respects.

This is not an easy matter to decide the cause or causes but at least there may be four possible considerations of the phenomenon:

(I) It may be due to the fact that the mutants tend to be less variable than normals, as BLAKESLEE (1920) suggested, though this does not mean that the dominants might be produced from the recessives, yet the fact may account for the excess of dominant.

(II) It may be due to the "Rückmutation." This phenomenon has been reported to have occurred very often since the case of *Mirabilis* investigated by CORRENS (1910) and of course this kind of mutation should have occurred often before this instance. IKENO affords an abundant example of this phenomenon on his *Plantago* varieties (IKENO, 1927) and the Rückmutation is, as the term indicates, a mutation from a once mutated character to its original type, so that there may be two cases that is one is to mutate from recessive to dominant character and the other is its reverse. IKENO, TERASAWA and HAGIWARA explain the phenomenon on their own

plants in this way. The nature of this phenomenon can be proved by the offspring.

(III) It may be due to the failure of distinction between the recessive character and the dominant one owing to the extremely low degree of the expression of the character in question which might be caused, in my view, by the environmental conditions in some individuals. I have sometimes experienced the difficulty in distinguishing the fasciated stem from the normal one in such a case when the phenomenon appeared on the stem-tip only. Such cases were met with on the plants sown in later time of the season, but in such cases I used a lens and succeeded in distinguishing the stem-tip which, when fasciated, exhibits, generally, a linear shape while when normal a conical one on the tip. It is very likely that we might fail to distinguish them correctly if the linear shape of the stem-tip be very short or the fasciation be very slight in its degrees owing to some environmental conditions, say, to sowing in later time of the season. Then the number of normal individuals will be greater than the expectation, but in such a case the failure would be detected by growing the progenies.

(IV) It may be of "feigned" or "false normal" as IMAI calls it in his case (IMAI, 1926). Discrepancy caused in this way can also be detected by raising the next generation.

Now turning back to the above mentioned considerations let us review the phenomenon occurring in my *Sesamum*. In my *Sesamum* the number of seeds in each capsule obtained from a fasciated individual as well as a normal one of the same race are nearly equal, and when the seeds are sown in an ordinary way they grow up well without special death of plants, so that the first consideration can not be applied to this case.

By the second consideration the phenomenon of "Rückmutation" is evidenced to take place not infrequently and in my case of *Sesamum* the same thing can with certainty be inferred to have taken place though not much in amount, for the F_3-generation in both cases can prove that, moreover the second series came down from the same stock with the first, so that when we are treating the one we might say that we have been in fact testing partly the nature of the other to some extent and we see that the results coincide with the above mentioned inference.

As it is evident there are several gradations in fasciation and

in snch a case as when the expression is very slight the plants are apt to be classified into the "normal" group notwithstanding they have genetically "fasciated" constitution. Again, if there were such a case in which the plants express the normal character while they have genetically a recessive constitution i.e., feigned or false normals of IMAI, what actually makes the difference between the third and the fourth case? Perhaps both cases might come under the same consideration. In the case of *Sesamum* the same thing might have taken place and thus the excess of dominants resulted.

Here I have come to conclude that the fact of producing the dominants from the recessives and accordingly the excess of dominants to recessives in *Sesamum* is partly due to the "Rückmutation" and partly to the failure of correct distinguishing of the characters. That the predecessors of the first and the second series used in these experiments are not of the same in genetical constitution might be an evidence of Rückmutation too.

V. Branched and unbranched Habit.

Branched or unbranched habit is one of the characteristics to certain species or varieties of plants in general. The cases of *Matthiola* investigated by Miss SAUNDERS (1911), *Helianthus* by SHULL (1908) and *Gossypium* by BALLS (1907) are well known examples displaying this habit. We have here another instance of branching and unbranching forms among *Sesamum indicum* and the habit is interesting in having a correlation between some other characters or genes to some extent.

Thus I-type has the branching habit and the plant body of this type branches out primarily at intermediate nodes, branching once to three times mostly, but the number of branches differs according to the condition of cultivation (See Pl. III, Fg. 7). When the plants are crowded in the field the branching habit is poorly displayed, while they branch out freely when they are cultivated scattered in fertile soil.

II-type is almost devoid of branching habit in an ordinary culture, but when the plants are cultivated in rich soil giving much space to each individual, they incline to branch out very poorly at characteristically lower spots of the plant body as is shown in Pl. III, Fig. 8.

III-type is almost devoid of the branching habit too in an ordinary culture as in the case of II-type, but the branching habit is displayed more highly than II-type and less than I-type when the plants are cultivated in rich soil and have much space to grow for each individual as is shown in Pl. III, Fig. 9.

On the whole we may say that II- and III-type have an unbranched habit and I-type has a branching one, and these habits more or less fluctuate according to the environmental conditions such as space, nature of soil, light, moisture etc.

A. First Series.

F_1-GENERATION. The plants of this generation have come out having many branches nearly like those of I-type, so that the habit of branching is perfectly dominant over unbranching as can be seen in Pl. IX, Figs. 43, 44.

F_2-GENERATION. The segregation of the characters or the genes is obvious in this generation but the strength of branching gene seems to be suppressed to some extent by the external conditions, so that the numerical ratio of segregation may not be in accordance with the expectancy, but in this case also we might say the segregation is seemingly incomplete.

In one of the lots raised in 1922 the F_2-individuals were classified into three groups by the progeny-test in the next year and they are:

Homozygous branching		Heterozygous branching		Homozygous unbranching
4	:	12	:	8

If we assume the whole population, that is 24 in number, of this generation to make the 1:2:1 ratio and calculate the deviations from the expectation we obtain -0.33, 0.00 and $+0.33$ respectively and ± 0.35, ± 0.41 and ± 0.35 for their mean errors respectively too.

In this calculation we see that all the deviations are more or less smaller than the corresponding mean errors, therefore even in this case the population is appropriately to be thought to come out in the ratio of 1:2:1 as was expected to come.

F_3-GENERATION. The individuals of this generation that is the progenies of the heterozygous F_2-plants as regard branching genes have been raised in 1923 as was mentioned above and the numbers

of branching and unbranching individuals were 70 and 41 respectively.

If we assume the population to have segregated in the ratio of 3 : 1 and calculate as the foregoing case we obtain −0.48 and +0.48 for the deviations and ±0.10 and ±0.16 for the mean errors for each term of the ratio respectively.

We see here that the deviations are three times larger than the corresponding mean errors, so that the assumed ratio of segregation is hardly fulfilled. In this case, however, it is very probable that some of the individuals having the branching constitution genetically are classified into the unbranched group owing to the poor development of branches influenced by the external conditions.

B. Second Series.

F_1-GENERATION. The individuals of this generation were raised in 1924 and they were of the same nature as that of I-type in regard to the character in question, that is branching is dominant over unbranching as in the case of the first series.

F_2-GENERATION. The individuals of this generation were raised in 1925 and there were 65 in number. They were classified into three groups by their progeny-test as in the first series and they are as follows:

Homozygous branching		Heterozygous branching		Homozygous unbranching
14	:	36	:	15

When we calculate the above mentioned individuals as segregated in the ratio of 1 : 2 : 1, we obtain −0.14, +0.22 and −0.08 for the deviations and ±0.21, ±0.25 and ±0.21 for the mean errors respectively.

We see from the calculation that any deviation is smaller than the corresponding mean error, so that all the deviations may appropriately be supposed to be due to errors of random sampling; that is the population has come out in the ratio as we expected to come.

F_3-GENERATION. Among the 65 individuals of F_2-generation 36 individuals have segregated into two types, that is, branching and unbranching types, and the rest bred true to their parental type. These 36 individuals, therefore, have been proved to be heterozygous branching as is shown in the above calculation and their progenies were 275 in all. Among these 275 individuals 160 were branchings and 115 unbranchings, and when we calculate the deviations and

the mean errors assuming the whole population to have segregated into the ratio of 3 : 1, we obtain −0.67 and +0.67 for the deviations and ±0.10 and ±0.10 for the mean errors respectively.

The result of this calculation shows us that the segregation is not in accordance with the expected ratio and in this case unbranchings are too many against the others. This excess for 3 : 1 ratio is undoubtedly due to the suppression or to the undeveloped condition of the branching habit as in the F_3-generation of the first series, and if we examine the case by progeny-test the individuals will no doubt come near the 3 : 1 ratio as all the individuals of F_2-generation did come.

C. Conclusion and Discussion.

As far as my experiments are concerned all the above mentioned results indicate that the branching habit in *Sesamum* is dominant over unbranching and this character is displayed by one-gene difference and it segregates after the simple Mendelian ratio, but the dominant character is sometimes suppressed or remains undeveloped or conversely the recessive character is sometimes obscured by producing very small branches which, however, are not similar as the dominant branches according to the conditions of environment as in the case of fasciation, and accordingly the numerical ratios may not sometimes be in accordance with the expected Mendelian ratio but this will be verified if we examine the plants by progeny-test.

Some investigators have already made experiments on this character and have reached to the same results as mine, such as SHULL (1908) with a variety of *Helianthus annuus* and Miss SAUNDERS with *Matthiola incana* (BATESON, 1913).

In the case of *Helianthus* SHULL found that sometimes the ratio of the branched to the unbranched does not come forth in 3 : 1, and he ascribes the excess of the branched, contrary to my case in the direction, to the conditions of culture, and in the case of Miss SAUNDERS the branched form was shown to be dominant over the unbranched one and in F_2-generation the unbranched type is said to have reappeared, but to regret the ratio has not been determined.

ABE (1919) made some experiments on the characters of *Sesamum*

indicum and he concludes that the branching habit is dominant over the unbranching, and in F_2-generation of White × Black and its reciprocal crossing together he obtained 112 branchings vs. 68 unbranchings. Based on his results when we calculate the deviations and the mean errors of the individuals of the classes, assuming that they have segregated into a dominant and a recessive class in the ratio of 3 : 1 respectively, we obtain ± 0.51 for the deviation and ± 0.13 for the mean error and here we see a great excess in the part of the branchings. Such is the case of his experiments and he concludes that the irregularity in the ratio of 3 : 1 compared with the expectation is perhaps due to the transplanting, for he believes that the habit is very much easily to be affected by the methods of culture, i.e., when the plants are transplanted the branching habit is better developed than when grown directly in the situation from the seeds.

Of the characters of sesame varieties enumerated by HOWARDS and KHAN (1919) branching and unbranching habits are stated, but there is nothing alluded to the genetical behavior of the characters.

Now let us consider the causes of excess of unbranchings in the ratio of 3 : 1 when judged by the external appearance in F_2-generation.

Branching habit is very easily affected firstly by the amount of space of cultivating ground and secondly by the nature of the soil where they are growing. As McDOUGALL (1927) states concerning the space, the first case is generally recognized fact autoecologically, i.e., when the plant has ample space it produces branches more profusely than when it is in reverse conditions; and as is stated above as the second cause the fact that the plant when grown in fertile soil it branches out more profusely than when it is in a reverse condition is also well recognized, so that when a plant has ample space and grows in fertile soil it is in a very favorable condition for branching.

ABE'S interpretation of the branching habit is to be accounted for by the above mentioned first cause, because when transplanted the plants are each apt to have more ample space than when grown directly from the seeds on the ground where in the latter case the plants are apt to have to grow crowdedly. Such principles are early known among the hemp-growers who do not desire to have the

plants branching out freely and they are utilized by not giving much space to grow.

WHITE (1917) also seems to grant the variability of this character in peas and he writes as follows:

"......The unbranched varieties of peas are said to branch profusely under the climatic conditions of the Pacific coast region of the United States......" "Examples showing the direct influence of a changed environment could be given by the hundred, did space permit."

Anyhow the branching habit seems to be affected very easily to the plus direction or to the reverse, and this would be, in all probability, the cause of excess of one class to the other or at least the cause of derangement of the ratios.

D. BACK-CROSSINGS.

As we see in Table III, under the heading of branches, the total number of individuals having branches is 139 and that of those having none is 166. The ratio of the two numbers may be granted to be nearly 1:1 for the deviation from the expectation is ± 0.09 while the mean error is ± 0.06, but in this case the ratio in the population of each year does not show well the 1:1 ratio. This will perhaps be due to the fluctuation caused by the different environmental conditions of the year.

E. MORE EXPERIMENTS.

With the hybridization-making between I- and II-type I made the same thing between I- and III-type, and between II- and III-type as was already stated. Examining the behavior of this character displayed in the F_1-plants of I × III, and of II × III we find the same nature of the character in question as that of I × II, and in F_2-generation the segregation of genes as well as the character is carried on in both hybrids as we see in Pl. III, but as the branching habit of III-type is originally stronger than that of II-type in grades, it makes more difficult to classify the population correctly than in the case of F_2-generation by an external inspection only.

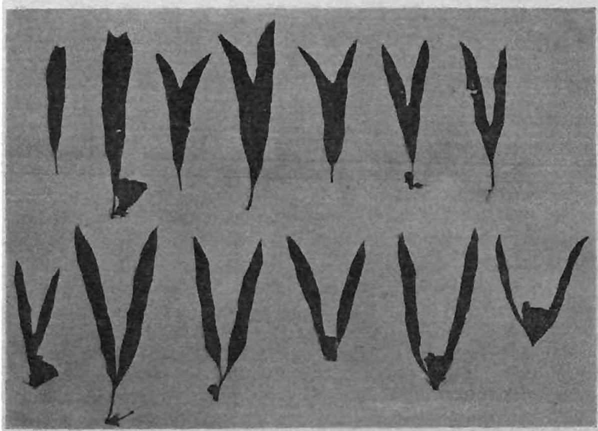
Summing up the results of the experiments stated in the foregoing two sections (D, E) we come to the same conclusion as before and the derangement of ratios is also accounted for in the same cause.

VI. Simple or compound Leaves.

Leaves of all the forms of this species have petiolated lamina but no stipules. We see, however, two slender rather minute stipule-like appendages in the base of each leaf. They are really the bracts or subtending leaves (Tragblätter) to the accessory buds, of which will be more fully explained later on.

In I-type the lamina is three or four lobed or deeply parted or sometimes so deep as to make compound leaves which are to be seen usually on the intermediate part of the stem, but towards the top of the stem the leaves become simple and lanceolate in shape as is usually the case in many plants (Pl. I, Fig. 1; Pl. IV, Fig. 10).

Morphologically, in general, simpleness or compoundness of leaves is one of the characteristics of certain plants, for this habit is so definite that the character can partly be utilized by taxonomists in classifying plants, and most plants have either one of these two forms and less commonly have both forms which are then



Text-fig. 2. Combined leaves in various degrees of combination, taken from plants of II-type.

termed dimorphic. I-type has such dimorphic leaf as is shown in Pl. I, Fig. 1; Pl. IV, Fig. 10, although the dimorphism in this type is not so clearly displayed.

The leaves of II-type are nearly the same in shape and in size with the simple leaves of I-type and in this type compound leaves have never been observed. This is one of the characteristics distinct from I-type (Pl. I, Fig. 2; Pl. IV, Fig. 11). Sometimes combined lanceolate leaves or leaf-twins are found in the plant body of II-type and in such a case combined fruits or twin-fruits are very often formed correspondingly on the base of such leaves.

The degrees of combination of such leaves is variable and when two leaves are highly combined the outline of the whole shape looks like one leaf with a notch at its distal end, but the fact that the whole is due to the result of combination of two leaves is easily recognizable in having two midribs of the original component leaves.

When the leaves combine poorly the outline looks like a big fork as is shown in Text-fig. 2, and Pl. V, Figs. 18, 19, 20, 21 and 22.

This phenomenon is one of the examples of synanthy and such leaves have never been observed in I- and III-type. The leaves of III-type rather resemble those of II-type in shape and in size, but rarely compound leaves as those of I-type are observed as is shown in Pl. I, Fig. 3; Pl. IV, Fig. 12. The appearance of the compound leaves in I-type seems to associate with that of the branches which vary to some extent according to the environmental conditions.

On the whole, however, the destitute of compound leaves seems to be one of the characteristics of II-type, that is to say, the leaves of this type are simple, or in other words, I- and III-type have dimorphic leaves while II-type has monomorphic ones; and the characters are definite so that they may be taken as subject for investigations.

A. Second Series.

F_1-GENERATION. The individuals of this generation of the hybrid between I- and II-type have compound leaves besides the simple ones, and in F_2-generation the heterozygotes segregate, so that the compoundness of leaves is dominant over the simpleness of the same, or we might say perhaps more appropriately in this case the dimorphism of leaves is dominant over the monomorphism.

F_2-GENERATION. The individuals of this generation were 60 in number and among them there were 42 plants having the compound leaves besides the simple ones and 18 plants having only the simple leaves.

If we assume the ratio of these observed numbers to be 3:1 and calculate deviations and mean errors we have ± 0.2 for the former and ± 0.22 for the latter. The result of the calculation shows that the assumption of the ratio of segregation follows the simple Mendelian rule and that the character is displayed by one-gene difference.

When the 42 individuals of the dominant type of this generation were classified by the nature of their progenies and arranged together with the recessive ones, that is 60 in all, into homozygous dominants, heterozygous dominants and homozygous recessives we have 7:35:18 respectively which should be taken as the ratio of segregation. In this ratio the first term is too small for the theoretical one, that is 1:2:1, which is to be expected to have if the segregation and recombination of genes had been regularly carried on and displayed their true nature.

F_3-GENERATION. The progenies produced from the heterozygous dominants in the F_2-generation have been grown and in examining them there were 189 dimorphic plants and 186 monomorphic ones. There is too great difference between the numbers of these two classes to make 3:1 ratio which was to be expected.

B. THIRD SERIES.

F_1-GENERATION. The individuals of this generation displayed the character of dimorphism with the exception of 1% of monomorphism. In this case the dimorphism may be taken as the dominant character over the monomorphism though theer was seen a little exception.

F_2-GENERATION. There were 65 individuals of this generation and among them 37 displayed the dimorohic character and the rest the monomorphic one. The number of the dimorphic individuals is too small to make a ratio of 3:1 with the monomorphic ones.

F_3-GENERATION. Among the progenies of the heterozygous dimorphic individuals of the F_2-generation there were 84 of dimorphic individuals against 186 of monomorphic ones, so in this case

the monomorphic class is too large to form 3:1 ratio.

C. Fourth Series.

F_1-Generation. The individuals of this generation were over a hundred and they expressed the dimorphism excepting nearly 10% of monomorphism.

F_2-Generation. The individuals of this generation were raised from the dimorphic plants of the preceding generation and we obtained 47 dimorphic plants and 49 monomorphic ones. In this case we see that the ratio of these two types is almot exactly 1:1 which shows the monomorphic plants are too many against dimorphic ones for the first assumption.

D. Back-crossing.

The results of the back-crossings concerning the leaf-form performed in 1928 and 1929 (see Table III) do not agree either with the 3:1 ratio or 1:1, but rather come near to the ratio of 15:1 in reverse order.

As to the cause of these discrepancies observed in the above mentioned experiments I like to consider in the next section.

E. Conclusion and Discussion.

The expression of the character may be designated as dimorphism of leaves vs. monomorphism but in this case of investigation we may designate the one as compound leaves and the other as simple ones in regard to the leaf-form themselves.

As to the phenomenon of the dimorphism in leaves several interpretations have been put forth (Babcock and Clausen, 1918), but it really is explained by the gene-theory.

In the F_1-generations of several experiments the compoundness seems to be dominant over the simpleness almost perfectly, and in F_2-generation the character has been shown to be expressed by one-gene difference but in subsequent generations sometimes the observations showed the excess of the simples to the compounds for expected ratios very irregularly. Moreover, from the individuals having simple leaves in F_2-generation, some ones having compound leaves have come forth segregating in the F_3-generation, that is the

recessives seem to produce the dominants as in the case of stem-forms.

What makes such an excess of simples to compounds or why the dominant type comes from the recessive one?

The excess of simple leaves or at least irregularity of ratios seems to be due to the unstableness of the expression of the character in the mode of the activity of the gene, or in other words, the character-expression is altered by the degrees of vigor due to the environmental conditions at large. Thus HOWARDS and KHAN (l. c.) state as follows:

"As a rule the leaves of this crop are entire except when the vegetative vigor is great as happened in 1909 at Pusa." "Most of the plants had divided leaves and very few entire-leaved plants were seen." "In the following year, when the plants were sown later and the vegetative vigor was less, entire leaves were common." "It would appear likely therefore that the form of the leaf depends on the conditions of growth and in any case further study of this leaf character is required before it can be used for breeding purpose."

We observed very often, among many individuals, such plants having so deeply parted simle leaves as to be taken as compound leaves and if conditions be favorable to vigor such leaves might have been compound.

In dimorphic leaves such transitional forms can be observed in other plants, though not compound, as *Lindera triloba*, BLUME, *Lindera obtusiloba*, BLUME, *Eucalyptus globulus*, LAB., *Gossypium herbaceum*, L. etc.

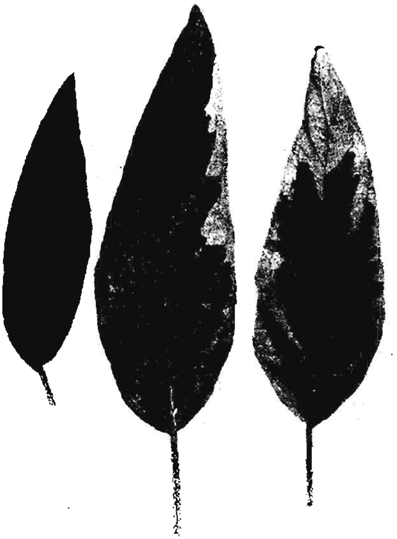
All these things indicate how the leaves are unstable in their form and that how difficult it is to distinguish them correctly.

Still there is some reason to think that the irregularity of the ratio is partly due to the loss of compound leaves by wind or rain or by other accidents if the examining time is a little too late when the large and old leaves are easily broken off. Moreover, the compound leaves are not produced on the upper part of the stem and when the fruits come to mature the leaves fall off, so that the examination of leaves in such a time might be led to error.

The phenomenon that the compoundness, the dominant character, seems to come from the simpleness, the recessive character, does not seem to be due to a mutation but it may be due to the fact that we take some individuals of real dominant character as those of recessive one on account of the above mentioned reasons.

VII. Variegation.

I have never observed any variegation in the plant body of the parent stocks of either type even during a long culture, but once



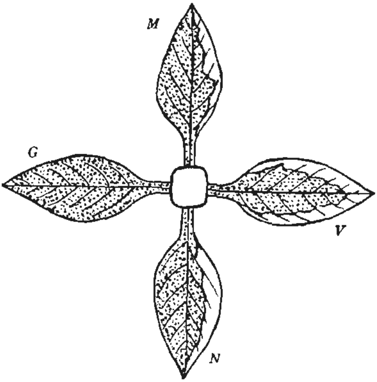
Text-fig. 3. Three leaves produced on the adjacent two nodes of the same plant.

in one of the F_1-individuals of I × II in 1917, and in the second time in one of the F_4-individuals of the hybrid between "Early ripening" and I-type in 1931, I noticed the phenomenon as is shown in Text-fig. 3.

When first appeared I cropped some seeds by self-fertilization

and have sown them the next year, but no variegated plant has been obtained although there were more than 50 individuals grown.

The variegation of the second time is interesting. Its quadrangular stem half vertically altered its nature, for the leaves on one side were all green as is shown in Text-fig. 4, *G*, and those on the opposite side were variegated as in *V*, while those on the



Text-fig. 4. Diagrammatic view of the mosaic of the plant body.

remaining two sides which take the position between the foregoing two were nearly half variegated as are shown in Text-fig. 4, *M* and *N*, the whole feature forming a mosaic pattern on the plant body. (Compare the Text-fig. 3 with Text-fig. 4 and imagine the mosaic variegation).

I cropped self-fertilized seeds from the flowers separately produced on these three different directions, *M* and *N* being taken as one and the same direction, and raised the offspring from them.

The plants sprung from the seeds taken from the capsules produced in the axils of all variegated leaves (*V*) were 35 in number, the plants sprung from the seeds taken from the capsules in

the axils of the half variegated leaves (*M, N*) were 50 in number and those from the seeds on all green leaves were 83 in number. In examining them we did not observe any variegated plant at all.

A. DISCUSSION.

Before entering into the consideration of the variegation in *Sesamum indicum* let us examine the nature of the phenomenon in general.

There are several types of variegation of leaves or stems, considered not only from the external appearance but also from the physiological or genetical stand point.

When we restrict the meaning of inheritance as the transmission through only the nucleus of germ cells these types are placed under two different headings, the one being a hereditary transmission and the other non-hereditary. Thus when we classify the several types mentioned under the "classification of chlorophyll inheritance" schemed by CHAPIN (1914) we may write down as follows:

Hereditary transmission:

(1) The cases of *Mirabilis Jalapa* investigated by CORRENS (1909-a), of *Plantago major* by IKENO (1917, 1923, 1927), of *Zea Mays* by LINDSTROM (1918), of *Pharbitis Nil* by MIYAZAWA (1918, a, b), IMAI (1919), MIYAKE and IMAI (1920) and YASUI (1920) are a few examples of transmission after the simple Mendelian rule and they can be classified in the first category.

Generally the variegation is recessive to normal green and the offspring of the self-fertilized F_1-plants come segregated in the ratio of 3:1 etc. according as the number of genes, though in some of the plants the phenomenon of "Rückmutation" was observed to take place as in the case of IKENO's *Plantago* (IKENO, 1923, 1927). Producing albinos or pallid plants is to be treated in this category.

Non-hereditary transmission:

(2) The cases of *Mirabilis Jalapa albomaculata* investigated by CORRENS (1909, b), of *Antirrhinum majus albomaculatum* by BAUR (1910), of *Primula sinensis* by GREGORY (1915) and of *Hosta japonica*, f. *albomarginata* by YASUI (1929) are a few examples of transmission of the phenomenon through the transmission of plastids etc. other than nucleus, and in tkese

cases the so-called maternal inheritance is developed. These cases can be classified in the second category.

(3) The cases of *Abutilon striatum* investigated by BAUR (1906), of *Capsicum annuum* by IKENO (1930) show very peculiar nature in the transmission of the variegation, i. e., the plants transmit their character through the aid of infection, so that the phenomenon is, by some investigators, called infectious chlorosis. The cases may come under the third category. Variegations of this category are often displayed in very ambiguous way and the diseased parts of the plants, usually the leaves, are, in my observation, not sharply defined in contradistinction to other category of variegations.

(4) Still the variegation caused by graft-hybrids may be classified as the fourth category. The phenomenon and its causes are too familiar to describe here.

The case of my sesame does not seem to come under the second or third or fourth category, judged from their appearance of the phenomenon. Then it will necessarily come under the first category. It is, however, very curious to have neither variegated plants nor albinos from the seeds which produced on the axils of the green and the variegated leaves, because when the variegated plant belongs to the first category as I presumed some of the offspring would have come true to the parent plant and they would have displayed variegation after the Mendelian rule.

Then I am inclined to think that the capsules from which the seeds were taken, had produced on the normal portion of the stem, independently of the leaves, otherwise the type would belong to some of the non-Mendelian transmission mentioned above.

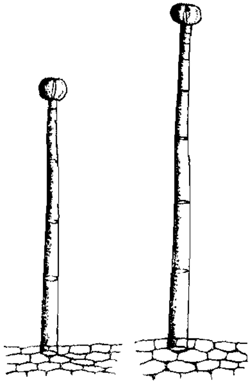
As to the phenonmenon Sô (1921) and IMAI (1928) made public their idea but it can be discussed in different ways in regard to the definition of inheritance or Mendelian inheritance etc.

VIII. Long and short Hairs.

Hairs on the sesame plants are not limited to some special regions of the plant body or they appear more or less in almost all the parts of the plants, i. e., on stems, leaves, flowers, fruits etc., but the most favorable part for investigation is in the stems as

there are much more hairs than in any other parts, hence the experiments on hairs is considered in this part only.

The hair is glandular having a stalk and it secretes much viscous substance, especially so when the plant is in the flowering time. The gland usually consists of four cells and has a globular shape, but the stalk consists of five to eleven, sometimes twelve cylindrical cells in a single row and forms a simple halter-shaped rod as is shown in Text-fig. 5; Pl. VI, Fig. 31.



Text-fig. 5. Glandular hairs taken from I-type plant.

There is a wide range in the length of hairs and this is mainly due to the number of cells which compose the stalk and also the length of each cell. Of these two factors in the hair length the former affects the entire length more largely than the latter. I-type has long hairs in addition to the shorter ones while II- and III-type have only shorter hairs as is shown in Pl. VI, Figs. 31, 32 and 33.

It might be thought at first that the longer hairs and the shorter ones on the plant body of I-type belong to two distinct categories as in the case of wheat awns and felts investigated by HOWARD (1916), but in measuring and plotting them to curves and testing by hybridization it was found that the fact is not so, but rather that the hairs of that type are only of long kind with wide range of variation while those of II- and III-type are of only short ones.

Tables IV, V and VI will show the average length of hairs on the plants of I-, II- and III-type respectively, and the curves in Text-fig. 6 constructed on the above mentioned tables will show how the hair length varies.

TABLE IV.

Hair-length on stem of I-type.

v	f	*	v	f	*	v	f	*
1	3	1.5	15	37	18.5	29	3	1.5
2	26	13.5	16	22	11.0	30	5	2.5
3	73	36.5	17	19	9.5	31	4	2.0
4	78	39.0	18	14	7.0	32	3	1.5
5	152	76.0	19	13	6.5	33	3	1.5
6	95	47.5	20	16	8.0	34	2	1.0
7	75	37.5	21	6	3.0	35	5	2.5
8	72	36.0	22	8	4.0	36	1	0.5
9	46	23.0	23	9	4.5	37	3	1.5
10	58	29.0	24	5	2.5	38	2	1.0
11	34	17.0	25	12	6.0	39	1	0.5
12	27	13.5	26	6	3.0	40	1	0.5
13	25	12.5	27	8	4.0	41	1	0.5
14	23	11.5	28	4	2.0		n=1000	500

TABLE V.

Hair-length on stem of II-type.

x	f	*	v	f	*
1	45	22.5	6	37	18.5
2	92	46.0	7	10	5.0
3	316	158.0	8	6	3.0
4	328	164.0	9	1	0.5
5	164	82.0	10	1	0.5
				n=1000	500

TABLE VI.

Hair-length on stem of III-type.

v	f	v	f	v	f
1	8	8	33	15	2
2	28	9	23	16	2
3	96	10	17	17	1
4	186	11	7	18	2
5	352	12	6	19	2
6	170	13	4	20	1
7	57	14	3		n=1000

In the Tables IV, V and VI the class-value (v) is expressed with scale numbers and as each scale is 79μ the actual length of hairs is easily obtainable in multiplying 79 by the number of the scales. The frequencies in Tables IV and V (those columns having asterisks) are reduced to half the numbers actually obtained so as to plot the curves based on them. Table VI is not used for the curve (Text-fig. 6).

When we calculate the statistical constants from these tables and arrange them we have the following table:

TABLE VII.

Type	M	σ	v in %
I-type	9.96±0.23	±7.28±0.16	±73.09±2.35
II-type	3.67±0.04	±1.24±0.03	±33.78±0.84
III-type	5.33±0.07	±2.22±0.05	±41.65±1.08

As the Table VII shows the differences between the constants of I-type and those of II-type are the largest of all, so that it will be convenient to investigate the genetic behavior of hair length with such types as I vs. II and in the present work they are chiefly used for this purpose. In the subsequent investigation of this character I do not measure the length each time, for it is too much work for minor importance but we could make distinctions between the individuals as to whether they come under I-type or II-type by a sole inspection in F_1- and F_2-generation and so forth.

In the seedling time of I-type there appear white hairs on the stem and as it grows taller, the hairs seem to increase in number as well as in length. Toward the blooming time the hairs near the top of the stem become so conspicuous that the upper part of the stem is quite covered with woolly hairs as is shown in Pl. I, Fig. 1, but when this time passes on and the stem grows still taller towards the maturity of fruits the hairs become comparatively thin and consequently less conspicuous, probably due to the fact that the emergency of hairs does not keep pace with the growth of the stem, so that the critical time of examination is at the blooming time of the first few flowers.

In the seedling time of II-type the stem has white hairs as in that of I-type but the hairs do not seem to increase in number and in length in contradistinction to I-type, and rather tbey seem to decrease toward the flowering time probably in the same reason

just as mentiond about the I-type.

The seedling of III-type cannot be distinguished from that of the preceding two forms in appearance when it is young, but as it grows, the hairs do not increase in number and in length so that the features become almost similar to that of II-type.

A. First Series.

F_1-GENERATION. As we see in Table VII the mean of the hair-length of I-type is 9.96 ± 0.23 and that of II-type is 3.67 ± 0.04. Again the mean of the hair-length of I×II-F_1 is 8.64 ± 0.21 as is shown in Table VIII while that of the reciprocal crossing is 8.30 ± 0.19 as is shown in Table IX, and as the behavior of the inheritance of the character in question seems to be of the same fashion in the direct and the reciprocal crossing, we may take the results and count them together; then the mean is 8.47 ± 0.14 as is shown in Table X.

Based on these results we can say that the hair-length of the hybrid between I- and II-type is nearly intermediate in degrees or "long" is imperfect dominant to "short".

Generally dominance or recessiveness is now not considered to be an important matter in hybridization as was once valued but if we want to express the behavior of the character in one of the alternative terms we could adopt the MORGAN's method (MORGAN, 1919) which is to be judged by the frequency curve or polygon constructed on the character of the individuals of the F_2-generation.

In the MORGAN's method the curves are to be plotted based on the population of the F_2-generation but instead of that we might take the hair-length, in this case, of two parents and that of the F_1-generation and compare them. Thus I plotted three curves in Text-fig. 6 and two of them are based on Tables IV and V which show the hair-length of I- and II-type respectively and the remaining one is based on Table X which shows the hair-length of F_1-population taking the individuals of I×II-F_1 generation together with those of its reciprocal one.

We see in the Text-figure 6 that the curve based on the F_1-population almost quite overlaps the curve based on the table of I-type, while it is apart from the remaining one based on the population of II-type. Judged from these curves we may say the longer hair or I-type dominates the shorter one or II-type. (See Pl. VI, Figs. 31, 32 and 34).

TABLE VIII.

Hair-length on stems of I×II-F_1.

v	f	v	f	v	f	v	f
1	2	13	13	25	6	37	2
2	9	14	10	26	4	38	2
3	28	15	11	27	3	39	1
4	66	16	9	28	2	40	1
5	212	17	8	29	3	41	1
6	189	18	7	30	2	42	2
7	112	19	4	31	1	43	1
8	98	20	7	32	2	44	1
9	59	21	6	33	1	45	1
10	51	22	4	34	1	46	1
11	25	23	6	35	2	47	1
12	16	24	5	36	1	48	1
							n=1000

M=8.64±0.21 σ=±6.64±0.15 v=±78.86±0.23%

TABLE IX.

Hair-length on stems of II×I-F_1.

v	f	v	f	v	f	v	f
1	1	14	12	27	1	40	0
2	10	15	10	28	3	41	1
3	35	16	7	29	1	42	1
4	75	17	6	30	1	43	0
5	113	18	4	31	2	44	0
6	222	19	6	32	2	45	1
7	199	20	4	33	1	46	0
8	95	21	7	34	2	47	1
9	69	22	2	35	2	48	1
10	29	23	5	36	1	49	1
11	22	24	7	37	1		n=1000
12	16	25	4	38	1		
13	13	26	2	39	1		

M=8.30±0.19 σ=±5.95±0.13 v=±71.66±2.28

Class values are expressed with scale numbers and each scale corresponds to 79μ.

TABLE X.

Hair-length on stems of I×II-F_1 and II×I-F_1 taken together.

v	f	f. reduced to 1/4	v	f	f. reduced to 1/4
1	3	0.75	26	6	1.50
2	19	4.75	27	4	1.00
3	63	15.75	28	5	1.25
4	141	35.25	29	4	1.00
5	325	81.25	30	3	0.75
6	411	102.75	31	3	0.75
7	311	77.75	32	4	1.00
8	193	48.25	33	2	0.50
9	128	32.00	34	3	0.75
10	80	20.00	35	4	1.00
11	47	11.75	36	2	0.50
12	32	8.00	37	3	0.75
13	26	6.50	38	3	0.75
14	22	5.50	39	2	0.50
15	21	5.25	40	1	0.25
16	16	4.00	41	2	0.50
17	14	3.50	42	3	0.75
18	11	2.75	43	1	0.25
19	10	2.50	44	1	0.25
20	11	2.75	45	2	0.50
21	13	3.25	46	1	0.25
22	6	1.50	47	2	0.50
23	11	2.75	48	2	0.50
24	12	3.00	49	1	0.25
25	10	2.50		n=2000	500.00

$M=8.47\pm0.14$ $\sigma=\pm6.31\pm0.10$ $v=\pm74.49\pm2.42\%$

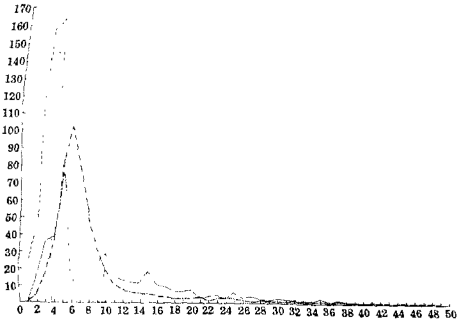
Class values are expressed with scale numbers and each scale corresponds o 79μ.

The frequencies are reduced to 1/4 original so as to take the equal total umbers those of the parents which are shown in Tables IV, V and VII.

Based on this table, one of the three curves of Text-fig. 6 is plotted and it is epresented by the half-solid line.

F_2-GENERATION. In 1922 the seeds cropped from the plants of $'_1$-generation in the same series were sown and 41 F_2-plants were aised. Some of these individuals, however, died before expressing ertain characters in full, so that the number of individuals to be

taken as representatives of the characters is in some cases 41 or less than that in others.



Text-fig. 6 Frequency curves for length of hairs based on Tables IV, V and X. The frequency members are in each case reduced to one fourth original. I-type is drawn with solid line, II-type with dotted line and F_1 of the hybrid with half-solid line.

In regard to the hair-length of those plants among 41 individuals there were only 26 which were taken as surely proved to be relied upon, and even these 26 individuals were proved to consist of three types, i. e., I-type, II-type and the hybrid-type or the F_1-type.

Although the measuring of the hair-length of these 26 plants was not undertaken, that there were the above mentioned three types among them was, with certainty, judged by inspection and by means of the progeny test.

Thus the individuals of F_2-generation were classified into three groups: the first being a homozygous long hair class comprising 6 individuals, the second a heterozygous long hair class comprising 14 individuals and the third a homozygous short one comprising 6 individuals. When we calculate the population assuming to have segregated genotypically into three classes in the ratio of 1:2:1 we obtain the results shown in Table XI.

We see here that all the deviations are smaller than those corresponding mean errors so that the assumption of the segregation is

TABLE XI.

	Observed		Expected	Deviation	
Assumed types	Absolute	per 4	per 4	Obs.-Expect.	m_4
Homo. longs	6	0.9231	1.00	−0.0769	±0.34
Hetero. longs	14	2.1538	2.00	+0.1538	±0.39
Homo. shorts	6	0.9231	1.00	−0.0769	±0.34
Total	26	4.0000	4.00	0	

to be relied on or the fact will show that the deviations may reasonably be supposed to be due to errors of random sampling.

As is mentioned above I took up 26 individuals from 41 as the population of F_2-generation. Some of them, however, had their progenies so scanty or none that they could not prove the nature of their predecessors and such individuals of F_2-generation are omitted.

F_3-GENERATION. The behavior of the F_2-individuals had been ascertained by the progenies and among them the heterozygous longs, 14 in number, have segregated into three types as their heterozygous parents did, and the numerical ratio is as follows:

Homo. longs		Hetero. longs		Homo. shorts
30	:	61	:	30

All these results show how closely the observed ratio comes near the expected one and this shows that the hereditary behavior follows the simple Mendelian rule.

B. THIRD SERIES.

F_1-GENERATION. The plants of this generation were raised in 1924 and the character of the plants is the same as that of the F_1-plants obtained in the first series.

F_2-GENERATION. In 1925 I cropped some individuals of F_2-generation and I could distinguish three types among them in regard to the length by inspection as well as the progeny-test as the following ratio:

Homo. longs		Hetero. longs		Homo. shorts
18	:	33	:	14

When we calculate the above individuals assuming them as

segregated into three classes in the ratio of 1:2:1 we obtain the following.

TABLE XII.

	Observed		Expected	Deviation	
Assumed types	Absolute	per 4	per 4	Obs.-Expect.	m_4
Homo. longs	18	1.11	1.00	+0.11	±0.21
Hetero. longs	33	2.03	2.00	+0.03	±0.25
Homo. shorts	14	0.86	1.00	−0.14	±0.21
Total	65	4.00	4.00	0.00	

We see from the table that any of the deviations is smaller than the corresponding mean error, so that the deviations may reasonably be supposed to be due to errors of random sampling.

In connection with the F_2-generation of this series let us calculate the products of the two years together which were presented in Table XI and XII, then we have the following:

TABLE XIII.

	Observed			
Year.	Population	Homo. longs	Hetero. longs	Homo. shorts
1922	26	6	14	6
1925	65	18	33	14
Absolute tolal	91	24	47	20
Observed nos. per 4		1.05	2.07	0.88
Expected nos. pes 4		1.00	2.00	1.00
Deviation		+0.05	+0.07	−0.12
m_4		±0.18	±0.21	±0.18

In this case we see from the table that any of the deviations is smaller than the corresponding mean error, so that the deviations may also reasonably be supposed to be due to errors of random sampling.

All the results of the F_2-generation seem to show that the hereditary behavior of hair-length follows the Mendelian rule and in the case of *Sesamum* the character of hairiness is displayed by one-

gene difference and this may be more proved in the subsequent generations.

F_3-GENERATION. In 1926 I have grown the plants of this generation of this series and from the results of the classifying I saw that among the longs, 18 individuals bred to their type and all the shorts, 14 in number, also bred true to their type but the remaining longs, 33 in number, came segregated into at least a long class and a short one. This shows that the 33 individuals were heterozygous longs, and their progenies, 252 in number, were classified as in Table XIV.

TABLE XIV.

	Observed		Expected	Deviation	
Assumed types	Absolute	per 4	per 4	Obs. -Expect.	m_4
Homo. longs	71	1.13	1.00	+0.13	±0.11
Hetero. longs	120	1.90	2.00	−0.10	±0.13
Homo. shorts	61	0.97	1.00	−0.03	±0.11
Total	252	4.00	4.00	0.	

Although the Table XIII shows obviously that the segregation is into 1:2:1 ratio yet the results of calculation of the sum of the crops in the two years show the same thing as in Table XV.

TABLE XV.

Year	Homo. longs	Hetero. longs	Homo. shorts	Total
1923	30	61	30	121
1926	71	120	61	252
Absolute total	101	181	91	373
Observed per 4	1.08	1.94	0.98	4.00
Expected per 4	1.00	2.00	1.00	4.00
Deviation	+0.08	−0.06	−0.02	0.00
m_4	±0.09	±0.10	±0.09	

In Table XV we see that any of the deviations of the observed numbers from the expected ones is smaller than the corresponding mean error, so that the deviations may reasonably be supposed to be due to errors of random sampling.

C. BACK-CROSSINGS.

A back-crossing between I×II-F_1 and I-type was performed in 1928 and obtained 42 individuals. In examining them there were 20 longs and 22 intermediates in length. The ratio of these numbers is almost exactly 1 : 1 as is expected to be if we assume the character to be displayed by one-gene difference, and long is imperfect dominant to short and segregate after the Mendelian rule.

Again back-crossings between I×II-F_1 and II-type were performed in 1928, 1929 and 1931 and obtained 305 individuals. In examining them there were 153 intermediates and 152 shorts in length as is shown in Table III. This ratio is exactly 1 : 1 as was expected to be on the same assumption as before.

D. RESULTS OF EXPERIMENTS WITH I×III AND WITH II×III.

As is shown in Table VII the hair length of III-type is 5.33 ± 0.07 on an average and now when we make hybrids between this and I-type having the hair length of 9.96 ± 0.23 on an average(see Table VII) we obtain the F_1-individuals having the hairs of somewhat intermediate length, (Pl. VI, Figs, 31, 33, 35) but we could say as in the case of F_1-generation of I×II, the long is dominant over the short.

In F_2-generation the individuals appear in two types; the one has long hairs and the other short ones. Among the F_2-individuals, 232 in number, which were raised in 1918, those with long hairs were 160 and those with shorter ones were 72. If we expect the segregation in the ratio of 3 : 1 then the deviation of the observed number from the expected one is ± 14.00 and the standard deviation is ± 6.63. The deviation is pretty large yet the total number is rather small, and the deviation is within three times the standard deviation, so that the error is reasonably to be supposed to be due to random sampling.

Again, we see that the hair length of II-type is 3.67 ± 0.04 and that of III-type is 5.33 ± 0.07 on an average as is shown in Table VII. These hair lengths seem to be constant to their own types although the difference is not so conspicuous as that between I- and II-type. So that I assumed the character of the hair in both types to be shorter in comparison with that of I-type and I classified them in the same category as is shown in Pl. VI, Figs. 32 and 33.

The F_1-individuals of these two types do not show much difference from the parents as is also shown in Pl. VI, Fig. 36, and in F_2-generation it is to be supposed appropriately that the segregation must have taken place in the ratio of 3-long to 1-short as these three types stand in the multiple allelomorphs for the character in question, but it is very difficult to distinguish them among the population only by inspection because the extent of fluctuations of the character is pretty large and when plotted in curves the segregated three types overlap one another.

E. Conclusion and Discussion.

From the results of my experiments on the character of long and short hairs I may draw the conclusion as follows:

1. Hair-length in I-, II- and III-type is constant to their own types and the hereditary character in I- vs. II-type is displayed by one-gene difference; and the character in I- vs. III- as well as in II- vs. III-type holds the same relation as I- vs. II-type.

2. The character of long hair is imperfect dominant over that of short hair.

3. The genes and accordingly the characters segregate after a simple Mendelian rule.

Now let us consider the characters of hair-length as well as the presence and absence of hairs in plant bodies in general, and compare the case of my *Sesamum indicum.*

A brief account is given of the results of investigations done by several experimenters in his classical book by Bateson (1913, p. 19). Since then several other experimenters have investigated the same character, such as Fraser on oat, Belling on beans, Ikeno on willows, and Miyake and Imai on foxglove etc.

Among the experiments hitherto done the case of *Lychnis* by de Vries, that of *Matthiola* by Bateson and Saunders, and the same by Correns (Bateson; 1913, p. 20) are a little different from mine in having such materials as one of them which is hoary and as the other which is entirely glabrous. But the hereditary character of this category is that the hairiness is perfectly dominant over the glabrousness.

The case of *Digitalis* by Miss Saunders (1918) and of the same plant by Miyake and Imai (1920) are different from those foregoing

cases as well as mine, for one of the materials is thoroughly hoary while the other is partially glabrous. The results of the experiments with this category represent that the partial glabrousness is dominant over the thorough hoariness.

The case of oat by FRASER (1919) also is a little different from the foregoing ones. According to him the variety called Sixty Day oat is practically devoid of all hairs but occasionally a few basal hairs are present though they are short and very sparse. The other parental type called Burt has a dense tuft of hairs which have been called medium in length. In the hybrid between Burt and Sixty Day oat the basal hairs are observed to be somewhat intermediate in length and in density, but rather strongly inclined toward the condition found in the Sixty Day oat.

From the data obtained in the F_2 and F_3 generations he concluded that the medium type of basal hairs is recessive to short or lacking and the characters are displayed by one-gene difference.

My case of *Sesamum* resembles that of the oat rather than the cases of *Lychnis*, *Matthiola* and *Digitalis* with respect to the hair-length, but hereditary nature of mine is quite contrary to that of the oat, for, in my experiment, as is stated already, the long hair is dominant or nearly so over the short.

JOHN BELLING (1914) investigated hereditary behavior of hair on different kinds of beans. One of his materials has long hairs and the other short; in this respect the materials resemble those of mine but his object of investigation seems to be on the qualitative nature of hairs, i. e., stinging brittles, tomentum and fine down, and not on the hair-length.

The results of IKENO's experiments concerning the leaf hairs of some *Salix* are interesting (IKENO, 1918, 1922). One of them is that of the hybrids between *Salix multinervis* and *Salix gracilistyla*, and the other is that of those between *Salix multinervis* and *Salix viminalis*.

In the former case glabrousness of leaves is dominant, and in the latter the hairiness is dominant or at least intermediate, just contrary to the other.

Again the result of the same author concerning the catkin hairs of the hybrid between *Salix multinervis* and *Salix gracilistyla* is rather unique, for in the F_1-generation two types appeared but he concludes on firm foundation that the hairiness of catkins of *Salix gracilistyla* is dominant to the less hairiness of *Salix multinervis* as

the result of one-gene difference and he ascribes the appearance of less hairiness of M-type in F_1-generation to the imperfection of dominance but not to Mendelian segregation.

Comparing my case with the first of IKENO's we find the latter to be different in having the glabrous plant for one parent and in the second case of the same author we find a point of resemblance in having hairs on both parents but its aim is quite different in finding out the character-inheritance of hair-density.

Looking over all the above mentioned experiments and their results we do not find any case comparable with mine which concerns somewhat a quantitative inheritance of hair-length.

The experiments on length of parts or a whole plant-body hitherto done by many investigators on plants of sweet pea, tomato, beans, snapdragons and Indian corn etc. resemble rather mine in regard to the character, the "length" itself. Of these experiments the case of maize experimented by EMERSON and EAST (1912) approaches to mine for the situation is quite quantitative.

In some of their experiments EMERSON and EAST studied the number of nodes per stalk and the length of internodes separately both of which undoubtedly make up the whole length of the stalk.

The case of the hair length of *Sesamum* resembles very much that of the stalk length of maize, for the whole length of the hair is, as is shown in the Text-fig. 5 and Pl. VI, composed of two elements, i. e., the number of nodes and the length of the internodes.

Whatever the hereditary modes of the number of nodes and the length of internodes may be, when treated as a whole length of stalk, no consideration is necessary, although desirable to study separately, so I did not study them but in a few examinations it seemed to me the length of such a hair is much more affected by the length of each internode rather than the number of the nodes.

IX. Accessory Flowers and Nectar Glands.

Flower buds of sesame appear in two different ways. In one way only one flower appears on the center of the leaf-axil and on both sides of this flower appear two nectar glands or extranuptial glands which resemble those on a cherry or peach leaf in shape. I- and II-type have their flowers in this way, so that these types have the fruits only one on each leaf-axil, while the glands shrivel

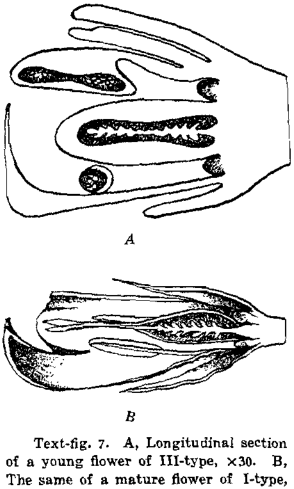
away as the capsules come to maturity. In another way a flower appears in the center of a leaf-axil early as in the first case and a little later two other smaller flowers develop simultaneously, one on each side of the first one, and then no nectarial gland develops. In this case it looks as though the side flowers have taken the place of the glands of I- and II-type as is shown in Pl. II, Figs. 4, 5 and 6. III-type has its flowers in this way so that in this type we have three fruits arranged collaterally on one axil as is shown in Pl. III, Figs. 7, 8 and 9.

Generally a flower may be considered to be a "Kurztrieb" on which floral leaves are arranged spirally or verticillately, so that in the case of III-type it may be said that we have two collateral short shoots or accessory buds on one leaf-axil.

A close examination, however, shows us that these collateral accessory buds are not really collateral but they are the secondary flower produced on each side of the first one, so that they have each a small subtending leaf to which was already referred and which looks like one of stipules of the subtending leaf of the first flower.

It is natural, therefore, that the first bud on one axil blooms early and its ovary becomes pretty large, then the side ones on the accessory branches follow, but as these three flowers become fruits it looks as if these fruits are produced simultaneously on each node of the stem of III-type while in I- and II-type there is but one fruit.

When we examine the inside of the flowers of I- and II-type we can easily see, *though by the aid of*

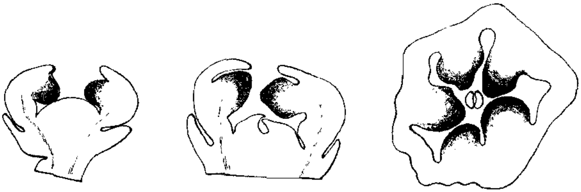


Text-fig. 7. A, Longitudinal section of a young flower of III-type, ×30. B, The same of a mature flower of I-type, ×4.

a low magnifying glass, an annular ridge around the base of the ovary as is shown in Text-fig. 7, A, B. This is a nectary within the flowers.

The flower structure of the accessory buds of III-type does not differ from that of I- and II-type as is shown in the Text-fig. 7.

Now let us examine the structure of the extranuptial nectaries of I- and II-type and compare with that of the accessory buds, i.e., of the side flowers of III-type. When we make sections of the extranuptial nectaries and examine closely we can see a calyx, a corolla, an androecium, and a gynoecium, each set consisting of modified 5 parts excepting gynoecium; and the whole look is very much like the miniature of an ordinary flower as is shown in Text-fig. 8, A, B, C.



A *B* *C*

Text-fig. 8. Sections of extranuptial nectaries; *A*, *B*, longitudinal and *C*, transverse sections. All from I-type, ×16.

When this organ is mature it secretes much sweet juice and preserves it in a depression which is formed in the center of the organ.

GOEBEL (1882) states in his book that there are various forms of nectaries and among them some are transformed from the entire foliar structures of the perianths, the androecium and even the gynoecium; and he gives, as examples of such transformation, an abortive stamen in Gesneriaceae, and an androecium in the female flower and a gynoecium in the male flower of *Cucumis Melo*.

In the case of *Sesamum* the petals and stamens (GOEBEL, l. c.) take part of the main secreting organ with which the other parts of the flower constitute the so-called nectary. The secreting portion of this modified stamen is composed of epidermal cells and several layers of cells under the epidermis.

As is mentioned above when they mature the nectaries give much sweet juice and a certain kind of ants is observed to collect upon them. Judging from the position and morphological aspect the nectaries of I- and II-type are the homologous organs of the accessory buds or flowers of III-type.

According to HOWARDS and KHAN (1919) the nature of the nectaries seems to be somewhat unstable, but in the materials in my hand a nectary-producing variety and a flower-producing one are stable in their existence with only exception of producing the antagonistic organs mixed on one plant thongh very rarely, so that the character is taken as the subject of investigation and sometimes I- vs. III-type or II- vs. III-type is used for the purpose.

ONO (1907) investigated some extranuptial nectaries and made a list of the Japanese native plants, including wild and cultivated ones which have such kinds of nectaries, and TAKAHASHI (1906) published a report of *Phaseolus radiatus, L.* var. *aureus*, PRAIN, and its allies which have such a kind of nectaries, but both of these investigators do not allude to the nectaries of the same nature in *Sesamum indicum.* If the nectary of the latter plant is hoped to be classified after TAKAHASHI's system it will of course be placed under the second type, and this will add a peculiar example to the list of the same category.

A. EXPERIMENTS WITH I- AND III-TYPE.

F_1-GENERATION. The hybrid plants between I-type and III-type have one flower on each leaf-axil and on both sides of that flower two nectaries appear just as in the feature of the I-type plants themselves, no matter which plant was used as ovule parent or pollen parent. Accordingly after maturity of the flowers we find only one fruit ripened on each axil of the plants of this generation as is shown in Pl. IX, Fig. 44.

As the nectaries may be considered to be modified flowers in nature the hereditary behavior of the F_1-generation might rather appropriately be concluded the "modifying power of flowers" to be completely dominant over developing the same, but now we may say, for simplicity, that the "appearance of nectaries" is completely dominant over that of the accessory flowers in both cases.

F_2-GENERATION. In 1918 F_2-individuals of the hybrid between

I- and III-type were cropped and in examining them 168 of I-typed and 64 of III-typed among 232 were classified. Assuming this to have segregated in 3:1 ratio we obtain ±0.10 for deviation from expectation and ±0.11 for the mean error in calculation. From the results we may conclude that the characters in question have really segregated in the assumed ratio so that the deviation can be thought to be due to the error of random sampling.

In 1929 another lot of F_2-individuals of the same hybrid were cropped, 98 in number. They were also classified into a I-typed group, containing 70 individuals, and a III-typed one containing 28 individuals, in regard to the character in question.

In calculation based on the above mentioned data we obtain ±0.14 for the deviation and ±0.17 for the mean error, assuming that the individuals have come segregating into 3:1 ratio. From the results we can conclude that they have actually segregated as the assumption and that the deviation is due to the error of random sampling.

F_2-GENERATION OF THE RECIPROCAL HYBRID. In 1926, 146 F_2-individuals of the reciprocal hybrid to the foregoing one were cropped and they were classified into a I-typed group containing 104 individuals and a III-typed group containing 42 individuals. In calculation on the basis of the assumption that they have segregated in the ratio of 3:1, we obtain ±0.15 for the deviation and ±0.14 for the mean error, so that we can say that the individuals have come segregated really as the assumption and that the error is due to the random sampling.

When we sum up the results of the above mentioned three cases including the reciprocal hybrid we obtain the following table:

TABLE XVI.

Hybrids	Year	I-typed ind.	III-typed ind.
I×III-F_2	1918	168	64
	1929	70	28
III×I-F_2	1926	104	42
Total		342	134

Calculating based on the results we obtain ±0.13 for deviation and ±0.08 for its mean error assuming to have segregated into

3:1 ratio. The deviation is a little larger than the mean error but the former is less than twice the latter so we may take the assumption as sure and we can learn that the character is displayed by *onegene difference* and it segregates in F_2-generation into 3:1 ratio following the simple Mendelian rule.

B. EXPERIMENTS WITH II- AND III-TYPE.

F_1-GENERATION. The individuals of this generation of the hybrid between II- and III-type have displayed the same nature as that of the hybrid between I- and III-type, i. e., the plants have appeard having one flower on each axil and on both sides of that flower two neactaries appeared. This is true with the reciprocal hybrid.

F_2-GENERATION. In 1926, 166 F_2-individuals of the hybrid between II- and III-type were cropped and they were classified into two groups. The one is II-typed group containing 125 individuals and the other is III-typed one containing 41 individuals.

In calculation based on these numbers and assuming that they have segregated in the ratio of 3:1 we obtain $\pm$7.01 for the deviation and $\pm$0.13 for the mean error, so that the individuals are appropriately to be thought to have segregated really as the assumption and the deviation is due to the error of random sampling.

In the same year 172 F_2-individuals of the reciprocal hybrid to the above were cropped and they were classified into two groups as the foregoing one. The one is II-typed containing 135 individuals and the other is III-typed one containing 37 individuals. Calculating them on the basis of these numbers and on the same assumption as before we obtain $\pm$0.14 for the deviation and $\pm$0.13 for the mean error so that in this case the individuals are thought to have behaved in the same manner as the above one too.

There are some other data concerning the character in question but for the present purpose no further verification is thought to be necessary.

C. CONCLUSION AND DISCUSSION.

From the results of the foregoing experiments we can draw the conclusion that the appearance of the nectar glands is perfectly dominant over its allelomorph, i. e., the appearance of the accessory

flowers, in either case with I- and III-type or with II- and III-type, and in either way of hybridization, direct or reciprocal, in both cases is perfectly dominant over the reverse. It is concluded also that the characters are displayed by one-gene difference and they behave in inheritance after the simple Mendelian rule.

ABE (1919) informs, based on his experiments, that the presence of nectar glands is dominant over that of capsules and he presumes that the character will be displayed by one factor difference, but there is no more to verify his assumption in his experiments. HOWARDS and KHAN (1919) mentions the character in question in their report but they do not say anything about the hereditary behavior of the characters, while they assume that the plants *having three flowers on each leaf axil, develop little or no branch* on the plants. Then the character seems to have some linkage with branching habit but whether or not there is any linkage will be discussed later on.

X. Lips of Corollas.

There are two types of flower lips in their opening fashion. In one of them the flower opens wide and its upper lip bends backwards, while in the other the flower does not open so wide and it looks somewhat to be a truncated tube with only difference in having lower part of the margin projecting a little longer.

The flowers of I-type open following the first type of fashion and those of II- and III-type open following the second as is shown in Pl. II, Figs. 4, 5, 6. Sometimes, however, the flowers of II- and III-type are noticed to open a little wider than is said above, but the bending back of the upper lips, if ever, is rarely noticed. We can, then, distinguish the two different types in the opening fashion without much difficulty, so the characters are taken as the subject of investigation and one is designated as "opened" and the other as "closed".

The cause of this difference is not certainly known, but it has been found that the upper part of the margin of the closed flower *is tinged with green color, so that it seems to me that the part of* the flower cannot keep pace in development from the bud with other part of that flower and finally remain green.

A. First Series of I- and III-type.

F_1-GENERATION. The opening fashion of the corolla of F_1-plar produced by the crossing of I- and II-type is similar to that of type so that the "opened" is perfectly dominant over the "closed but the characters seem to be easily affected by the age of the pla even in one and the same plant or by the time of opening even the same day. In such a case we are apt to be misled in judgi the true nature of the flower only by inspection and thus t closed or at least "intermediate opened" might be taken as tr nature of that plant but it may be made clear by progeny test.

F_2-GENERATION. The segregation of the characters is obvio and among the F_2-individuals three types of corolla were distinguis ed by progeny test. For instance in one of the lots raised in 19 the individuals of this generation were classified as follows:

Table XVII.

Opened 21		Closed 7
Homozygous 8	Heterozygous 13	Homozygous 7

Although the number of the population is too small for holdir to be valid yet from the results we can infer that the character manifested by one-gene difference and that it behaves after tl simle Mendelian rule.

F_3-GENERATION. As we see in Table XVII, among the 2 opened individuals the 8 were proved to be homozygous and the 1 heterozygous and again the 7 closed ones were proved to be hom zygous by their progeny.

The progeny of these 13 heterozygous opened were 123 in nun ber and these individuals make up the F_3-population to be examine Among these 123 individuals 91 were opened and 32 were closed, s that it is quite obvious that the individuals have segregated phen typically into two groups in a ratio almost exactly of 3 : 1.

B. Third Series of I- and II-type.

F_1-GENERATION. The individuals of the same hybrid in th generation were of the same nature in the character in question a

that of the same generation of the first series, that is the opened is dominant over the closed.

F_2-GENERATION. *In* 1925 F_2-*generation* was *raised* and 65 *in*-dividuals were obtained. There were two phenotypical types and they were classified by inspection and progeny test as follows:

TABLE XVIII.

Opened 49		Closed 16
Homozygous 20	Heterozygous 29	Homozygous 16

In this table, just as in the Table XVII, we see that the individuals consist of three genotypical types and they come out in the ratio of 1:2:1 though these actual numbers do not appear exactly to be so.

When we bring the last two tables together and calculate we obtain the following table:

TABLE XIX.

Year	Homo. opened	Hetero. opened	Homo. closed	Total
1922	8.	13.	7.	28.
1925	20.	29.	16.	65.
Absolute total	28.	42.	23.	93.
Observed per 4	1.20	1.81	0.99	4.00
Expected per 4	1.00	2.00	1.00	4.00
Deviation	+0.20	−0.19	−0.01	0.00
m_4	±0.18	±0.21	±0.18	

We see in Table XIX that the deviations of the heterozygous opened and homozygous closed are each smaller than the corresponding mean error and although the deviation of homozygous opened is a little larger than the corresponding mean error yet it is very much smaller than twice the mean error. From these facts we can draw the conclusion that the character in question is, as is said above, manifested by one-gene difference and the allelomorphic characters segregate *after* the *simle Mendelian rule in the ratio* of 3:1 *or* 1:2:1.

F_3-GENERATION. These were 234 individuals of the progeny produced from the heterozygous forms in the preceding generation

by which the genotypic nature of their parents has been tested.

Among the individuals stated above (234 individuals) we could distinguish two types, the one is opened and the other closed. The opened individuals were 175 in number and the remaining 59 were closed. These two numbers approximately make the ratio of 3 : 1, for in calculation assuming thus, we have ±0.01 for the deviation and ±0.11 for the mean error, and the former is much smaller than the latter. If we take together the results of the two years, i. e., the result of the first series and that of the second, and calculate we obtain the following:

TABLE XX.

Year	Opened	Closed	Total
1923	91.	32.	123.
1926	175.	59.	234.
Absolute total	266.	91.	357.
Observed per 4	2.98	1.02	4.00
Expected per 4	3.00	1.00	4.00
Deviation	−0.02	+0.02	0.00
m_4	±0.09	±0.09	

As we see in Table XX the deviation is much smaller than the mean error so that the segregation can be said with much confidence to be in 3 : 1 ratio.

C. BACK-CROSSING BETWEEN I × II-F_1 AND II-TYPE.

It will be improper not to touch upon the results of the experiment on the same subject which is summarized in Table III. The opened and the closed individuals under the heading of flowers in the table do not make an exact 1 : 1 ratio, yet they make approximately that ratio as is expected in the back-crossing based on the assumption of the allelomorphs consisting of one-gene difference.

The individuals of the two classes are the same with those in the case of branched and unbranched (see Table III and the discussion of the character) and the discrepancy with the 1 : 1 ratio is accounted for in the fact that the appearance of the flowers is to be affected easily by environmental conditions, as in the case of

branching, the true nature of the character is sometimes mistaken.

D. Conclusion and Discussion.

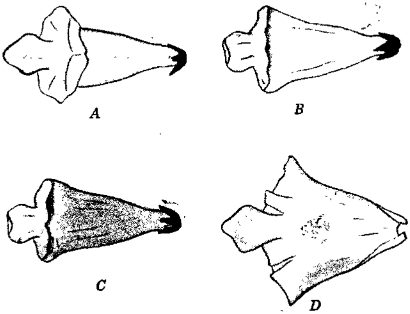
The characters of opened and closed corolla are manifested in one-gene difference and they segregate following the simple Mendelian rule. So far as I am aware none of the investigations of such nature of corollas has ever been reported.

The erect and the hooded standards of the flowers of sweet pea investigated by BATESON and PUNNETT (BATESON, 1913) somewhat resemble this case but the length of standards in those two kinds does not seem to be different and the hooded standard bends downwards instead of upwards, so that the cause or causes and the nature of corollas in those plants seem to be different from those of my case.

XI. Color of Corollas.

The flowers of sesame open themselves nearly in a horizontal position, and on the outer surface of their dorsal side they have more or less diluted color of "Phlox Pink" (RIDGWAY, 1912) due to the presence of anthocyanin in the cell-sap.

The color intensity is not of the same in all forms, so the



Text-fig. 9. Showing the flower color and patch inside the corolla.

flowers of III-type have deeper color and those of II-type have almost white color, while those of I-type have intermediate color of the foregoing two types as is shown in Text-figs. 9, A, B, C.

The early ripening form which has been used in my experiments later has much deeper color than any other type although this form belongs to II-type with regard to the color of the seed-coat. Some forms have a patch of fine purple dots on the inner surface of the ventral side of the corolla as is shown in the same figure, D; while the others have none. The existence of the patches seems to be independent of the external color of the corolla, but in some cases there may be some linkage between them.

Thus the color and the patch of the flower may be taken as the subject of investigation and for this purpose II- and III-type have chiefly been used.

A. Results of Experiments.

F_1-GENERATION. The individuals of the hybrid between II- and III-type have nearly intermediate color, so that the deeper color is imperfectly dominant over the very diluted color or nearly white, without regard to the way of hybridization, i. e., the results are the same which type was used as pollen parent.

F_2-GENERATION. The individuals of this generation produced from the hybrid between ♀II- and ♂III-type were classified by inspection as is shown in Table XXI, and the individuals of the same generation produced from the reciprocal hybrid, i. e., between ♀III- and ♂II-type were classified by inspection as is shown in Table XXII.

TABLE XXI. (Cropped in 1926)

III-typed	Intermediate	II-typed
31	89	46

TABLE XXII. (Cropped in 1926)

III-typed	Intermediate	II-typed
39	109	24

When we take the intermediate colass as clored and put it to-

gether with the III-typed or colored one and calculate them based on the Table XXI we obtain 3:1 ratio almost exactly, but when we calculate them based on the Table XXII in the same way the results do not come to the same ratio as the first one. Then when we calculate them assuming to have segregated in 15:1 ratio the results also do not fit good. When, however, we calculate them putting together the corresponding classes, good and bad, in the two tables and assuming them to have segregated in the ratio 3:1, we obtain ± 0.17 for the deviation and ± 0.09 for the mean error. The deviation in the last calculation is less than twice the mean error, so that it is very likely that they have come out really in the ratio 3:1 as we assumed.

Then why the segregation in the second case came out bad for the ratio of 3:1 while it came out fitting good in the first case seems to be a problematic matter, but as the external appearance of such a character as intensities of flower color can be very easily affected by both the external and internal conditions such as the durations of sun light and the ages of flowers etc. The deviations, therefore, can be attributed to the dissimilarity of those conditions or fluctuation and improper methods of inspections.

The best way to determine the true nature is, of course, to see the progeny but it does not seem to be worthy of spending much time and labor in obtaining their progeny for such a common matter.

B. Conclusion and Discussion.

The deeper color on the outside of the corolla in *Sesamum indicum* is imperfect dominant over nearly white or more appropriately saying over colorlessness. In the F_2-generation the allelomorphic characters segregate and they come out in 3:1 ratio.

Generally purple, violet, red, blue and other colors in flowers caused simply by the presence of anthocyanin is dominant, sometimes perfectly and other times imperfectly, over white or colorlessness and segregate in F_2-generation simply after the Mendelian rule. Many instances of this kind can be seen in literatures such as in BATESON's work but I am not yet aware of the reports concerning the flower colors of *Sesamum indicum* excepting that of HOWARDS and KHAN.

According to the last named experimenters (HOWARDS and KHAN, 1919) there are several different color types as is stated already, but in my experiments so many color types as they state seem not to be fixed but to be temporary appearance of fluctuations, and if there were so many, the distinction in the characters would be very difficult or almost impossible in so easily affectable characters as these.

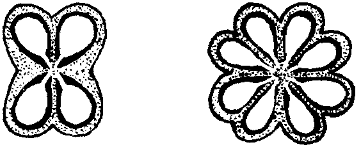
Whether or not the color genes have some linkage with other ones will be stated in later chapters.

XII. Number of Ovary-cells

Each set of flower parts consists of 5 members, but one of the stamens usually degenerates, and the pistil and accordingly the ovary consist of usually two carpels as the stigmas indicate it.

In such an ovary the cell is primarily divided into two cells by a partition wall excepting only the extreme upper part of the ovary and each cell is also divided into two by a thin membrane, so that there are four cells in each of which the ovules are arranged in a row. I- and III-type are provided with such an ovary, while II-type has an ovary which consists of more than two carpels, mostly three or four. In such an ovary as that of II-type there are six or eight cells since each original cell will be later divided into two.

As a rule, each carpel becomes to have two cells but very rarely the partition membrane in an ordinary cell does not develop, and then two rows of ovules are stowed up in a cell, otherwise a row of ovules is formed in a single cell and this is the usual case. (See Text-fig. 10, A; Pl. V, Figs. 23, 24, 25 and 26).



A B

Text-fig. 10; A, cross-section of a young fruit of I-type; B, the same of a young fruit of II-type.

Sometimes in II-type two pistils adhere and the ovary appears to be twin, and in such a case many cells are formed as is shown in the fruits in Pl. V, Figs. 27, 28, 29, 30. Such an ovary is of course abnormal, and that

this is due to the adhesion of two or more ovaries is clearly seen in the cross section of the fruits as well as the fork-shaped subtending leaves to which I have already alluded (Pl. V, Figs. 18—22, 27—30), then this is one of the examples of synanthy.

Such abnormal ovaries are exclusively to be found on the stem of II-type upon which the phenomenon of fasciation is also to be observed, both, perhaps, having a linkage to some degrees (Text-fig. 1).

III-type has the ovary of similar structure to that of I-type as has already been stated. Here we have two types, then, as to the number of the ovary cells, the one having two primary cells as in I- or III-type, and the other three to five primary cells as in II-type. I designated the former 2-celled ovary and the latter as many-celled one, and this is a good example of discontinuous variation.

Here we must be cautious to make the distinction between the many-celled ovary and the synanthial one.

A. First Series of I- and II-type.

F_1-GENERATION. As is stated already I-type has its ovaries with 2-cells and II-type has more than two as is shown in Pl. V. The individuals of this generation have their ovaries with two cells invariably. This shows that 2-celled ovary is perfectly dominant over many-celled one.[1]

F_2-GENERATION. The individuals of this generation appear in two forms, i. e., the one has 2-celled ovary like that of I-type and the other has many celled like that of II-type.

The many-celled individuals of this generation were all homozygous but 2-celled ones were of two kinds genotypically. This was proved by the progeny test and the result has come out to segregate as in the following table:

Table XXIII.

2-celled		Many-celled
Homozygous	Heterozygous	Homozygous
9	14	7

[1] Here by "many-celled" is meant those ovaries having more than two cells.

When we calculate the ratio of these numbers assuming to have segregated into three classes genotypically and compare them with 1:2:1 ratio we obtain the following:

TABLE XXIV.

Assumed type	Observed		Expected	Deviation	m_4
	Absolute	per 4	per 4	Obs.-expect.	
Homo. 2-celled	9	1.20	1.00	+0.20	±0.32
Hetero. 2-celled	14	1.87	2.00	−0.13	±1.15
Homo. many-celled	7	0.93	1.00	−0.07	±0.32
Total	30	4.00	4.00	0.00	

We see here that all the deviations are smaller than those corresponding mean errors, so that we might think that the segregation has really been carried on as the assumption.

F_3-GENERATION. The individuals of this generation were raised *from 14 heterozygous 2-celled ones in 1923 and among them there were 88 individuals of 2-celled ovary and 31 of many-celled one.* When we assume them to have segregated into two types in the ratio of 3:1 and calculate with the observed numbers, we have ± 0.04 for the deviation and ± 0.16 for the mean error, so that the segregation may be thought to have been carried on really as we assumed.

B. THIRD SERIES OF I- AND II-TYPE.

F_1-GENERATION. The individuals of this generation were raised in 1924 and they were of the same type as that of I-type in regard to the character of ovary cells, viz., 2-celled type is dominant over many-celled one.

F_2-GENERATION. The individuals of this generation obtained in 1925 were 65 in number and they were classified into three forms by progeny test as follows:

TABLE XXV.

2-celled		Many-celled
Homozygous	Heterozygous	Homozygous
22	32	11

Assuming the numbers to make the ratio of 1:2:1 let us calculate them, then we obtain the following:

TABLE XXVI.

Assumed type	Observed Absolute	Observed per 4	Expected per 4	Deviation Obs.-Expect.	m_4
Homo. 2-celled	22.	1.35	1.00	+0.35	±0.21
Hetero. 2-celled	32.	1.97	2.00	−0.03	±0.25
Homo. many-celled	11.	0.68	1.00	−0.32	±0.21
Total	65.	4.00	4.00	0.00	

In Table XXVI we see that the deviation of heterozygous 2-celled individuals is much smaller than the corresponding mean error and that the deviations of homozygous 2-celled individuals as well as the homozygous many-celled ones are smaller than twice the corresponding mean errors although the deviations of the latter two do not fall within their mean errors. From the results we may think appropriately that the segregation has been carried on as we assumed.

Now when we bring the results of the Tables XXIII and XXV together and calculate the ratio of their numbers we obtain the following:

TABLE XXVII.

Year	Homo. 2-celled	Hetero. 2-celled	Homo. many-celled	Total
1922	9.	14.	7.	30.
1925	22.	32.	11.	65.
Absolute total	31.	46.	18.	95.
Observed per 4	1.30	1.94	0.76	4.
Expected per 4	1.00	2.00	1.00	4.
Deviation	+0.30	−0.06	−0.24	0.
m_4	±0.18	±0.21	±0.18	

We see in Table XXVII that any deviation is smaller than twice the corresponding mean error so that the segregation of characters into 1:2:1 ratio may be thought to have really occurred in F_2-generation.

F_3-GENERATION. The individuals of this generation, i. e., the progeny of the heterozygous 2-celled plants of the preceding generation have been raised in 1926 and they were classified into two groups as the following:

2-celled individuals		Many-celled individuals
181	:	73

When we calculate the ratio based on these numbers, assuming them to have segregated into 3:1 ratio we have ± 0.15 for the deviation and ± 0.11 for its mean error. In this result we see that the deviation is smaller than twice the mean error, so that we may say that the segregation into 3:1 ratio has really taken place as we assumed.

Now when we bring together the two results of the F_3-generation, i.e., the result of F_3-generation in the first series and that of the third one, and calculate them we have the following:

TABLE XXVIII.

Year	2-celled	Many-celled	Total
1923	88.	31.	119.
1926	181.	73.	254.
Absolute total	269.	104.	373.
Observed per 4	2.88	1.12	4.00
Expected per 4	3.00	1.00	4.00
Deviation	-0.12	$+0.12$	0.00
m_4	± 0.09	± 0.09	

As we see in Table XXVIII the deviation is much smaller than twice the mean error, so that the segregation may be said with much confidence to have been carried on as we assumed.

C. BACK-CROSSING BETWEEN I × II-F_1 AND II-TYPE.

The results of the back-crossing between the F_1 and II-plant, performed in the three years, 1928, 1929 and 1931, are shown in Table III.

As we see in the numbers under the heading of ovary-cells in the table, the individuals having 2-celled ovary are 146 and those having many-celled one are 159 in totals. It is pleasant to see how the individuals obtained in 1929 and 1931 came out well in accordance with the ratio of 1:1, but as the result of the year 1928 does not

come out in the same ratio the total sums do not make the same ratio exactly, yet they show pretty well that the ratio is very near 1:1 and this also proves the assumption of the character is quite true.

D. Experiments with II- and III-type.

F_1-generation. Hybridizations between II- and III-type have been performed in 1925, 1926, 1929 and 1930, and many individuals of this generation were obtained. All the plants came out having ovaries of two cells as in the case of the hybridization between I- and II-type.

Reciprocal crossings in parallel with the above and many individuals were obtained. The plants of this generation had shown the same with the above in regard to the character in question.

F_2-generation. Tables of the results of the above mentioned two crossings in this generation will be more convenient to show what is the hereditary behavior of this character than the description of their nature, and the tables will hereafter be utilized in showing data concerning other characters than the present one.

Table XXIX.

F_2 of II×III in four years.

Characters		Purple dots in corolla		Fruits in each axil		Ovary cells		Colors of the seed-coat			
Year	Individuals	Present	None	1	3	2	∞	Black	Russet	Avellaneous	Cinnamon buff
1925	28			24	4	21	7	16	6	4	2
1926	166			125	41	120	46	97	29	29	11
1929	162			134	28	118	44	100	13	38	11
1930	375	281	94	270	105	292	83	236	53	66	20
Total	731	281	94	553	178	551	180	449	101	137	44

As we see in Table XXIX the plants having 2-celled ovary are 551 in number and those having many-celled ovary are 180. These two numbers almost exactly make the ratio of 3:1.

The Table XXX is the results in the F_2-generation of the reciprocal crossing to that shown in Table XXIX. As we see in this table the plants having 2-celled ovary are 553 in number and those

TABLE XXX.

F_2 of III×II in four years.

Characters		Purple dots in corolla		Fruits in each axil		Ovary cells		Colors of the seed-coat			
ear	Indi-viduals	Pre-sent	None	1	3	2	∞	Black	Rus-set	Avella-neous	Cinna-mon buff
925	18			11	7	13	5	12	3	3	0
926	172			135	37	118	54	99	32	30	11
929	164			136	28	123	41	96	16	35	17
930	406	305	101	299	107	299	107	244	55	77	30
'otal	760	805	101	581	179	553	207	451	106	145	58

ıving many-celled ovary are 207. These two numbers do not make ı exact 3:1 ratio, yet they may appropriately be granted to make ıe same ratio.

As this character behaves in the same way, either in direct or ı reciprocal crossing, the above tabulated two results can be taken ltogether but differently according to the different characters and alculate them. When we calculate the sums in this way and com-are the ratios with the assumed ones we can see them to make 3:1 atio almost exactly although it is not necessary to do so.

E. BACK-CROSSING BETWEEN II×III-F_1 AND II-TYPE.

Back crossing was performed between II×III-F_1 and one of the II-type in the years 1928, 1929 and 1931, and obtained 504 plants. In examining them in each year and totalling we obtained 245 plants having 2-celled ovary and 259 plants having many-celled one.

As 2-celled ovary is dominant to many-celled one it will be expected to have 1:1 ratio in the results and this is almost perfectly realized.

F. CONCLUSION AND DISCUSSION.

From the above mentioned results we can draw the conclusion concerning the characters in question as follows:

1. 2-celled ovary is perfect dominant over many-celled one and the character is manifested by one-gene difference and come out in F_2-generation after the simple Mendelian rule.

2. The results of experiments with II- and III-type show the same aspect in the hereditary nature as in those with I- and II-type.

The hereditary behavior of ovary cells or fruit cells in this plant is reported by ABE (1919). He concluded that the 2-celled capsule dominates over many-celled one, and that the character is perhaps manifested by one-factor difference. But his statement is very vague, perhaps containing some erroneous elements.

He means by "many-celled" those 2–6-celled fruits (l. c.) and by "2-celled" is apparently meant the original cell numbers each of which is usually to be divided into two cells by a false partition wall; so that his 2–6, when applied to my designation, is 4–12-celled, but among them 6–12-celled ones are not in reality a single fruit but a combination of two or more fruits mostly making a twin as is shown in Pl. V, Figs. 13, 14 and 15.

As far as my observation goes a fruit having the maximum number of cells is originally 5-celled or seemingly 10-celled one and although a 2-celled fruit is sometimes found in the same plant together with 3—5-celled ones yet this phenomenon is not common, so that by "many-celled" in my designation will mean originally 3—5-celled fruits sometimes with 2-celled ones. The reason why we should think the most cells of fruits are 5 is obvious, should we think first that the floral parts of this plant are pentamerous. I will discuss more fully about the combination of fruits later on.

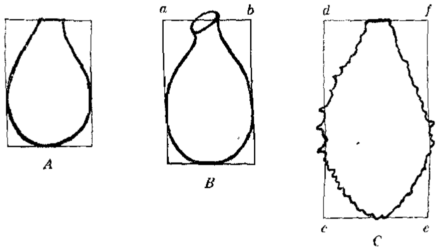
BATESON (l. c.) states in his book the results of the hybrids in tomato obtained by PRICE and DRINCARD (1908) who reported that the 2-celled type of fruit in this plant is dominant over many-celled one. Although I have not been able to see their original paper and also BATESON does not describe the hereditary behavior of the character in detail, it is supposed that the gene differece is one and the segregation might have followed the simple Mendelian rule, for this case very much resembles that of my *Sesamum indicum*. As BATESON states, the case of tomato is one of a few meristic features and so mine is another instance of the same category.

The behavior of meristic characters, however, have since been investigated in plants and animals by several authors and in some cases meristic characters are complicated genetically, although the generalization of dominancy can hardly be made, but I think there is a strong tendency of dominance of a scarcer number over a many-one.

XIII. Length and Breadth of Seeds.

The length and breadth of seeds are characteristically different and they give the special shape and size to their own types as is shown in Pl. VIII, Figs. 40, 41 and 42. The methods of measuring seeds are to take the widest distance, placing somewhat a flattened seed on a slide to express the *magnitude*, by the number of micrometer-scales as in the case of hair length, and one degree of the scale corresponds to 83.4μ as in Text-fig. 11.

In this case *if* the surface of the hilum is *in* coincidence with the level and make a right angle to the long axis as is shown in Text-fig. 11, *A*, the measuring is not hard, but if the surface of the



Text-fig. 11. Showing the method of measuring the regular as well as the irregular outline of seeds.

hilum does not stand in such a position as in the same figure B, the scale line is to place so as to pass the middle of the surface of the hilum as is shown in the line *ab*. Again as in the same figure *C* when the surface of the seed-coat has warts or prickles, the scale line is to place on the ground line of the surface, omitting the prickles which project from the ground level as *cd*, *ce* and *ef* of the figure.

In such a way when I measured the length and breadth of 400 *individuals of the seeds* of I-type, taking *them at random from a* bag, I obtained the results shown in Tables XXXI and XXXII. As we see in Tables XXXI-A, -B, -C and -D the seed length of this

type, obtained during four succeeding years (1923—1926), is almost constant and the average of these years is 33.35 scales as is shown in Table XXXII-A.

TABLE XXXI-A.

I-type, seeds cropped in 1923.

Length...x / Breadth...y	29	30	31	32	33	34	35	36	37	Total
18			1							1
19		1	1	3	3	2		1	1	12
20		1	4	4	5	3	2	1		20
21	1	3	3	9	8	6	2	1		33
22		1		15	22	17	3	2		60
23			3	15	40	62	34	3	1	158
24			1		15	44	37	4	1	102
25				1	2	6	3	1		13
26					1					1
Total	1	6	13	47	96	140	81	13	3	n=400

$M_x=33.65$ $M_y=22.70$

Class limits are placed on the middle line of each scale, making progression with the difference of a unit.

TABLE XXXI-B.

I-type, seeds cropped in 1924.

Length...x / Breadth...y	30	31	32	33	34	35	36	37	Total
19		1	2	3	1	1			8
20		3	10	8	3	2			26
21	2	8	16	13	8	5			52
22	1	4	22	30	26	12	2		97
23		1	25	41	32	15	2	1	117
24		1	7	23	28	12	5	2	78
25			2	4	5	6	3	2	22
Total	3	18	84	122	103	53	12	5	n=400

$M_x=33.34$ $M_y=22.53$

TABLE XXXI-C.

I-tpye, seeds cropped in 1925.

Length...x / readth...y	30	31	32	33	34	35	36	37	Total
19		1	2	1					4
20		2	6	5	1	1			15
21	1	12	22	15	6	4			60
22	2	8	21	35	23	8	2		99
23		3	17	54	41	14	6	1	136
24		1	5	15	23	19	7	1	71
25			1	2	3	5	3	1	15
Total	3	27	74	127	97	51	18	3	n=400

$M_x=33.32$ $M_y=22.55$

TABLE XXXI-D.

I-type, seeds cropped in 1926.

Length...x / Breadth...y	29	30	31	32	33	34	35	36	Total
19	1	5	2	1					9
20	1	3	13	8	3	2			30
21		1	7	33	20	9	1		71
22			5	30	75	37	3		150
23				6	30	44	22	1	103
24				2	3	11	13	4	33
25						3	1		4
Total	2	9	27	80	131	106	40	5	n=400

$M_x=33.08$ $M_y=22.06$

TABLE XXXII-A.

I-type, seed-length, average of 4 years.

Length...x / Year	29	30	31	32	33	34	35	36	37	Mean
1923	1	6	13	47	96	140	81	13	3	33.65
1924		3	18	84	122	103	53	12	5	33.34
1925		3	27	74	127	97	51	18	3	33.32
1926	2	9	27	80	131	106	40	5		33.08
Total	3	21	85	285	476	446	225	48	11	n=1600

$M_x=33.35$

TABLE XXXII-B.

I-type, seed-breadth, average of 4 years.

Breadth...y / Year	18	19	20	21	22	23	24	25	26	Mean
1923	1	12	20	33	60	158	102	13	1	22.70
1924		8	26	52	94	117	78	22		22.53
1925		4	15	60	99	136	71	15		22.55
1926		9	30	71	150	103	33	4		22.06
Total	1	33	91	216	406	514	284	54	1	n=1600

$M_y = 22.47$

TABLE XXXII-C.

I-type, correlation between length and breadth of seeds.
Samples obtained in 1923, 1924, 1925, 1926.

Length...x / Breadth...y	29	30	31	32	33	34	35	36	37	Total
18			1							1
19	1	6	5	8	7	3	1	1	1	33
20	1	4	22	28	21	9	5	1		91
21	1	7	30	80	56	29	12	1		216
22		4	17	88	162	103	26	6		406
23			7	63	165	179	85	12	3	514
24			3	14	56	106	81	20	4	284
25				4	8	17	15	7	3	54
26					1					1
Total	3	21	85	285	476	446	225	48	11	n=1600

Length: $M_x = 33.35 \pm 0.03$ Breadth: $M_y = 22.47 \pm 0.03$

$\sigma_x = 1.28 \pm 0.02$ $\sigma_y = 1.30 \pm 0.02$

$v_x = 3.84 \pm 0.07\%$ $v_y = 5.79 \pm 0.10\%$

$R_{xy} = 0.48 \pm 0.02$

TABLE XXXIII-A.

II-type, seeds cropped in 1923.

Length...x / Breadth...y	35	36	37	38	39	40	41	42	43	44	Total
18	1				1	1	1				4
19		1	2	1	3	7	3	1			18
20	1	2	2	6	18	25	18	7			79
21		1	10	20	32	33	22	3			121
22		1	12	26	40	30	13	3	1		126
23	1	1	8	9	11	7	7	2	1	1	48
24				1	2	1					4
Total	3	6	34	63	107	104	64	16	2	1	n=400

$M_x = 39.33$ $M_y = 21.27$

TABLE XXXIII-B.

II-type, seeds cropped in 1924.

Length...x / Breadth...y	34	35	36	37	38	39	40	41	42	43	Total
17				1	2	1					4
18		1	1	3	5	3	2	1			16
19	1	1	6	7	9	10	9	4	1		48
20	1	7	12	24	30	24	14	5	1	1	119
21	2	8	18	22	26	15	10	8			109
22	3	5	13	15	16	11	4	2			69
23	1	1	4	9	5	4	2				26
24			1	4	2	1	1				9
Total	8	23	55	85	95	69	42	20	2	1	n=400

$M_x = 37.82$ $M_y = 20.67$

TABLE XXXIII-C.

II-type, seeds cropped 1925.

Length...x / Breadth...y	34	35	36	37	38	39	40	41	42	43	Total
18						1	2				3
19			1	2	5	6	13	3	2		32
20	1	2	4	9	17	20	23	12	9		97
21	2	2	8	16	20	19	18	11	8		105
22	1	4	6	12	20	17	15	6	5	1	87
23		3	5	10	8	8	13	5	2	1	55
24		1	1	2	3	7	3	2	1		20
25								1			1
Total	4	12	25	51	73	78	87	40	27	3	n=400

$M_x = 38.86$ $M_y = 21.23$

TABLE XXXIII-D.

II-type, seeds cropped in 1926.

Length...x / Breadth...y	34	35	36	37	38	39	40	41	42	43	44	Total
17				1								1
18			1	1	1	4	3	2				12
19	1	1	2	4	11	14	7	5	1			46
20	2	4	11	12	14	16	8	7	6	1		81
21	4	8	18	19	20	19	10	8	8	3		117
22	2	5	5	22	23	25	11	5	3	1	1	103
23			2	6	9	10	3	3	1	1		35
24				3	1	1						5
Total	9	17	40	68	79	89	42	30	19	6	1	n=400

$M_x = 38.35$ $M_y = 20.94$

TABLE XXXIV-A.

II-type, seed-length, average for 4 years.

Length...x / Year	34	35	36	37	38	39	40	41	42	43	44	Mean
1923		3	6	34	63	107	104	64	16	2	1	39.33
1924	8	23	55	85	95	69	42	20	2	1		37.82
1925	4	12	25	51	73	78	87	40	27	3		38.86
1926	9	17	40	68	79	89	42	30	19	6	1	38.35
Total	21	55	126	238	310	343	275	154	64	12	2	n=1600

$M_x = 38.59$

TABLE XXXIV-B.

II-type, seed-breadth, average for 4 years.

Breadth...y / Year	17	18	19	20	21	22	23	24	25	Mean
1923		4	18	79	121	126	48	4		21.27
1924	4	16	48	119	109	69	26	9		20.67
1925		3	32	97	105	87	55	20	1	21.23
1926	1	12	46	81	117	103	35	5		20.97
Total	5	35	144	376	452	385	164	38	1	n=1600

$M_y = 21.03$

TABLE XXXIV-C.

II-type, correlation between length and breadth of seeds.
Samples obtained in 1923, 1924, 1925, 1926.

Length...x / Breadth...y	34	35	36	37	38	39	40	41	42	43	44	Total
17				2	2	1						5
18		2	2	4	6	9	8	4				35
19	2	2	10	15	26	33	36	15	5			144
20	4	14	29	47	67	78	70	42	23	2		376
21	8	18	45	67	86	85	71	49	19	4		452
22	6	14	25	61	85	93	60	26	11	3	1	385
23	1	5	12	33	31	33	25	15	5	3	1	164
24		1	2	9	7	11	5	2	1			38
25								1				1
Total	21	56	125	238	310	343	275	154	64	12	2	n=1600

Length: $M_x = 38.59 \pm 0.05$ Breadth: $M_y = 21.03 \pm 0.03$

$\sigma_x = 1.81 \pm 0.03$ $\sigma_y = 1.31 \pm 0.02$

$v_x = 4.69 \pm 0.08\%$ $v_y = 6.23 \pm 0.11\%$

$r_{xy} = -0.08 \pm 0.02$

Also as we see in Tables XXXI-A, -B, -C and -D the breadth the seeds of the same type is almost constant, and the average the four succeeding years is 22.47 in scales as is shown in Ta XXXII-B. The relative size of the seeds, i. e., length/breadth is this case 1.48, but more detailed calculations can be seen in Ta XXXII-C, and in the same table we can see the correlation coeffici between the length and the breadth of seeds which is in this c 0.48 ± 0.02. In this case the correlation (r_{xy} = 0.48) is as large 24 times the size of the mean error (m_{xy} = 0.02), so that we see tl there is practically some correlation existing between the two e ments, though not high.

Again when we measure the dimensions of 400 seeds of II-ty obtained during the same years as I-type (1923—1926), in the sa way as before, we obtain the results shown in Tables XXXIII a XXXIV.

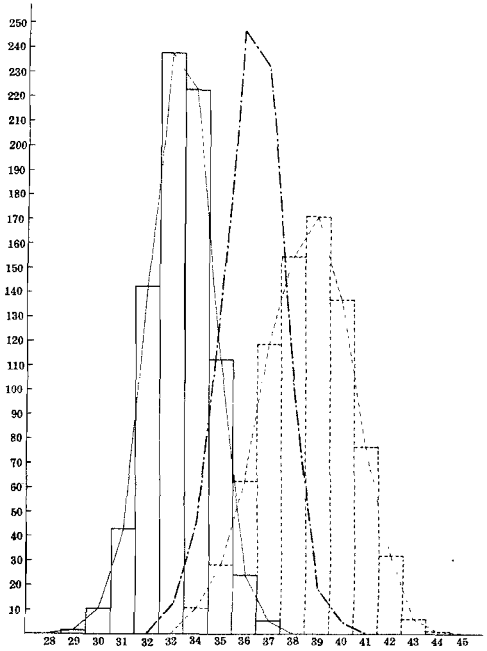
As we see in Tables XXXIII-A, -B, -C and -D the leng of this type is almost constant and the average for these years 38.59 as is shown in Table XXXIV-A. Also we see, in the sa tables, the breadth of seeds is almost constant in each of the fc succeeding years, and the average for these years is 21.03 in scales is shown in Table XXXIV-B. The relative size of the seeds, leng breadth, is 1.83, and this is much larger than the relative size I-type which indicates that the seeds of II-type are longer than th of I-type in their appearance.

The more detailed calculations are shown in Table XXXIV and as we see in that table the correlation (r_{xy}) between the t dimensions of the seeds is −0.08 and this is just 4 times as la as the mean error (m_{xy} = ± 0.02) or nearly 6 times as large as probable error, so that I do not think there is any considera correlation between the two dimensions, although the direction the correlation is reverse to that of I-type.

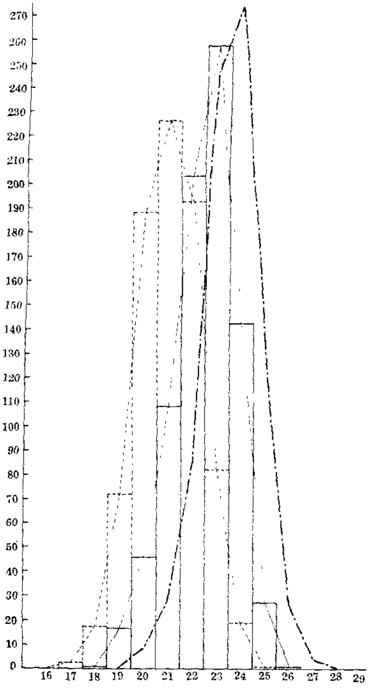
As we see in Text-figs. 11-A and 11-B the shape and the s of the seeds of the two types are not of the same feature and tl is apparently seen in the statistical constants of Tables XXXI, XXX XXXIII and XXXIV series respectively.

I sought a suitable index to represent the shape and the s of the seeds by a simple method and for this purpose I chose t relative size of seeds obtaining it by dividing the length by t breadth as was already used.

When we draw curves based on Tables XXXII-C and XXXIV-C we obtain the results shown in Text-figs. 12 and 13.



Text-fig. 12. Frequency curves for length of seeds based on Tables XXXII-C, XXXIV-C and XXXVI-C. The frequency numbers are in each case reduced to one half original. I-type is drawn with solid line, II-type with dotted line and F_1 of the hybrid with half-solid line.



Text-fig. 13. Frequency curves for breadth of seeds based on Tables XXXII-C, XXXIV-C and XXXVI-C. The numbers are in each case reduced to one half original. I-type is drawn with solid line, II-type with dotted line and F_1 of the hybrid with half-solid line.

As is shown in the coefficients the correlation between the length and the breadth of seeds in the two types are different not only in the magnitude but also in the direction, so that the characters may appropriately be thought as definite and be treated genetically for quantitative investigation.

Of the two dimensions, the length and breadth, the length of seeds will be considered first.

F_1-GENERATION. As is shown in Table XXXII-A the average length of seeds of I-type for four years,(1600 grains in total number), is 33.35 and the same of II-type is 38.59 as is shown in Table XXXIV-A; while the average length of the seeds of the hybrid between those two types is 36.32 as is also shown in Table XXXVI-A.

TABLE XXXV-A.

I×II-F_1, seeds cropped in 1923.

Length...x / Breadth...y	34	35	36	37	38	39	40	Total
20		1	3	1				5
21	1	4	5	2	1			13
22	1	5	14	7	4		2	33
23	2	32	39	30	9	2	1	115
24	1	16	53	66	16	5	1	158
25		5	10	28	15	3	1	62
26				6	5	1		12
27				1	1			2
Total	5	63	124	140	51	12	5	n=400

$M_x=36.56$ $M_y=23.63$

The length and breadth are represented by the scale numbers, one of which is actually 83.4μ.

TABLE XXXV-B.

I×II-F_1. seeds cropped in 1924.

Length...x / Breadth...y	33	34	35	36	37	38	39	40	Total
20		1	2	3	1				7
21	1	2	4	7	3	1			18
22	2	5	12	23	14	7	1		64
23	1	11	24	45	30	8	1	1	121
24	1	5	18	29	35	15	2	1	106
25		2	8	18	29	11	1		69
26			1	4	5	2	1		13
27					1	1			2
Total	5	26	69	129	118	45	6	2	n=400

$M_x=36.25$ $M_y=23.43$

TABLE XXXV-C.

I×II-F_1, seeds cropped in 1925.

Length...x / Breadth...y	33	34	35	36	37	38	39	40	Total
21	1	2	3	1	1	1			9
22	3	4	9	7	4	1			28
23	7	16	30	39	16	5	1		114
24	4	15	28	54	34	9	2	1	147
25		3	7	20	25	24	2	1	82
26			1	3	4	8	2	1	19
27							1		1
Total	15	40	78	124	84	48	8	3	n=400

$M_x=36.03$ $M_y=23.81$

TABLE XXXV-D.

I×II-F_1, seeds cropped in 1926.

Length...x / Breadth...y	33	34	35	36	37	38	39	40	Total
20		1	1	1	2				5
21		4	5	3	3	1			16
22	2	8	13	12	10	2			47
23	1	6	30	63	31	10	2		143
24		2	8	29	59	32	6		136
25			1	8	17	13	3	1	43
26				2	3	3			8
27						2			2
Total	3	21	58	118	125	63	11	1	n=400

$M_x=36.45$ $M_y=23.40$

TABLE XXXVI-A.

I×II-F_1, averaged seed-length of four years.

Length...x / Year	33	34	35	36	37	38	39	40	Mean
1923		5	63	124	140	51	12	5	36.56
1924	5	26	69	129	118	45	6	2	36.25
1225	15	40	78	124	84	48	8	3	36.03
1926	3	21	58	118	125	63	11	1	36.45
Total	23	92	268	495	467	207	37	11	1600

$M_x=36.32$

TABLE XXXVI-B.

I×II-F_1, averaged seed-breadth of four years.

Breadth...y / Year	20	21	22	23	24	25	26	27	Mean
1923	5	13	33	115	158	62	12	2	23.62
1924	7	18	64	121	106	69	13	2	23.43
1925		9	28	114	147	82	19	1	23.81
1926	5	16	47	143	136	43	8	2	23.40
Total	17	56	172	493	547	256	52	7	1600

$M_y = 23.57$

TABLE XXXVI-C.

I×II-F_1, correlation between length and breadth of seeds.
Samples obtained in 1923, 1924, 1925, 1926.

Length...x / Breadth...y	33	34	35	36	37	38	39	40	Total	Reduced to 1/2
20		2	4	7	4				17	8.5
21	2	9	16	16	9	4			56	28.0
22	7	18	39	56	35	14	1	2	172	86.0
23	9	35	116	186	107	32	6	2	493	246.5
24	5	23	70	165	194	72	15	3	547	273.5
25		5	21	56	99	63	9	3	256	128.0
26			2	9	18	18	4	1	52	26.0
27					1	4	2		7	3.5
Total	23	92	268	495	467	207	37	11	1600	800.0

Length: $M_x = 36.32 \pm 0.03$ Breadth: $M_y = 23.57 \pm 0.03$
$\sigma_x = \pm 1.24 \pm 0.02$ $\sigma_y = \pm 1.17 \pm 0.02$
$v_x = 3.41 \pm 0.06\%$ $v_y = 4.96 \pm 0.09\%$
$r_{xy} = 0.34 \pm 0.02$

The above mentioned number, i. e., 36.32 is the average length of the F_1-individuals and this is intermediate in size between those of the two parents, and when we take the average number of the two parents, i. e., $(33.35+38.59)\,1/2=35.97$, and compare the average length of the F_1-individuals we can see that the one is very near to the other.

When we plot curves based on these data we see that the F_1-area overlaps that of the homozygous long a little more than that of the

homozygous short as is shown in Text-fig. 12, where the curve of the F_1-length is drawn with half solid line omitting its rectangular histogram as the drawings are too much complex.

If we want to determine dominancy we may say, after the MORGAN's fashion, that the long is dominant over the short but this is not only so indifferent but also unimportant matter excepting to give the idea that the F_1-individuals are inclined a little more to long than to short, so I shall take the character of the F_1-plants as intermediate in regard to the character in question.

A. FIRST SERIES OF I- AND II-TYPE.

F_2-GENERATION. In this generation there are three different lengths that is a long, a short and an intermediate.[1] The individuals of this generation were 41 in number but those individuals which have value to decide the nature by their progeny are taken up even though the number of such progeny is small and thus I have taken up 27 individuals among 41.

The seed-length of the long individuals ranges from 51.50 to 48.00 and its average is 50.28 which corresponds to 38.59 of the average of II-type though a little deviation may be seen here. Based on the length of the individuals when we collect the longs from those 27 F_2-plants, we obtain 6 individuals and these should be expected to be homozygous for long and that is evidenced by the progeny.

The length of the short individuals ranges from 44.40 to 41.50 and its average is 43.19 which corresponds with an inevitable fluctuation to 33.35 of the average of I-type. When we collect, based on the length, the shorts from those 27 F_2-plants we obtain 6 individuals, and these are homozygous for short as is evidenced by the progeny.

The rest from 27 F_2-plants should be heterozygous ones for seed-length and there are 15 individuals which range from 53.00 to 43.50 and its average is 48.96 which corresponds to the average length of the F_1-individuals, that is 36.32, although the former is a little

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[1] In this series I measured the seeds by scales, one of which is about 64.7μ, so that the scale number is correspondingly larger than that of the second series which is measured by the scales, one of which is 83.4μ. One scale of the second series is therefore 1.29 times larger than that of the first one.

larger than the latter; and that these 15 individuals are heterozygous is also evidenced by the progeny.

When we assort the population of the F_2-individuals and calculate the deviations and mean errors on the assumption that they will make 1:2:1 ratio, then we have the following table as the result:

TABLE XXXVII.

	Observed		*Expected*	*Deviation*	m_4
Assumed type	Absolute	per 4	per 4	Obs. - Expect.	
Homo. long	6	0.89	1.00	−0.11	±0.33
Intermediate	15	2.22	3.00	+0.22	±0.38
Homo. short	6	0.89	1.00	−0.11	±0.33
Total	37	4.00	4.00	0.00	

In Table XXXVII we see that the deviations are all smaller than the corresponding mean error, so that the assumption of the ratio is really good fitting, in other words the segregation in the F_2-generation has been carried on as we assumed.

F_3-GENERATION. In this generation we have 6 families of homozygous shorts which descended from the preceding generation and the individuals of these families are 38 and the total length by scale is 1703.17, so that the average scale-length of each individual is of course 1703.17/38=44.82. We see that the last number, i.e. 44.82, is very near the average number, 43.19, of the same category of the F_2-generation.

We have also 6 families of homozygous longs which descended from the preceding generation and the individuals of these families are 50 and the total scale length is 2632.33, so that the average scale length of each individual is 2632.33/50=52.65. We see here that the average length, 52.65, is very near the average length, 50.28, of the same category of F_2-generation.

We have, again, 15 families of intermediate or heterozygous ones which descended from the same preceding generation and all the individuals of these families are 124. Among them I selected those individuals having the length of from 44.40 to 41.50 as homozygous short, and all the remaining as intermediate together with homozygous long ones.

Homozygous short can be distinguished almost without failure

from the rest as the length is comparatively small but among the remaining, intermediates can hardly be distinguished from the homozygous longs only by inspection, because the length of intermediates often overlaps that of homozygous longs when plotted in curves as was already stated. Thus the homozygous shorts is 33 and the remaining, including both the intermediates and the homozygous longs, is 91, and they make approximately the ratio of 1 to 3 respectively.

When we collect the lengths of 33 individuals of homozygous shorts we obtain 1528.02 and the mean length of these individuals is of course $1528.02/33 = 46.03$ which is not far apart from the mean of the 1600 homozygous I-type (see Table XXXII-A) that is $33.35 \times 1.29 = 43.02$.

Here we shall notice that the homozygous short have invariably the crystal of calcium oxalate on the wall and this phenomenon will be discussed more fully later on.

B. Second Series of I- and II-type.

F_2-GENERATION. The individuals of this generation were 65 in number and these individuals can be classified into three groups, that is a long, a short and an intermediate group.[1]

There are 23 homozygous longs, 26 intermediate or heterozygous longs and 16 homozygous shorts among those 65 individuals. When we calculate the deviations and the corresponding mean errors based on the number of these three groups, assuming to make 1:2:1 ratio, we obtain the following:

TABLE XXXVIII.

	Observed		Expected	Deviation	m_4
Assumed type	Absolute	per 4	per 4	Obs. -Expet.	
Homo. long	23	1.42	1.00	+0.42	±0,21
Intermediate	26	1.60	2.00	−0.40	±0.25
Homo. short	16	0.98	1.00	−0.02	±0.21
Total	65	4.00	4.00	0.00	

1) The dimensions in this series are measured by scales, one of which is 83.40μ

As we see in the above table the deviation of the homozygous short is much smaller than its mean error and the deviations of the two other groups are larger than their mean errors, but the latter two are within the twice their mean errors respectively, so that the segregation is appropriately to be thought to have been carried on the assumed ratio. The average length of 16 homozygous shorts of this generation is 542/16 = 33.82 which is very near the average length of I-type for the 4 years as is seen in Table XXXII-A. The average length of 23 homozygous longs is 896/23=38.96 which is also very near the average length of II-type for the 4 years as is seen in Table XXXIV-A; while the average length of 26 intermediate individuals is 955/26=36.73 which is also very near the average length of F_1-individuals as is seen in Table XXXVI-A.

We see here that the average length of intermediates is between the two others and that the homozygous short has invariably the crystal on the wall while the two others have none like that in the case of the first series.

F_8-GENERATION. In this generation we have 65 families which have descended from the 65 individuals of the preceding generation and the total number of the individuals of these families is 517.

Among these 65 families 16 are homozygous short and the total number of the individuals of these 16 families is 105 and all the scale lengths of these individuals are 3268, so that the mean scale length of each individual in the present generation is 3268/105=31.12 which is not far apart from the length of I-type (see Table XXXII-A). There are 23 homozygous longs among the 65 families and the total number of the individuals of these 23 families is 204 and their total scale lengths are 7220, so that the average length is 7200/204= 35.39 which also is not far apart from the length of II-type (see Table XXXIV-A).

Again among the 65 families 26 are heterozygous long or intermediate and the total number of the individuals is 208. These 208 individuals could be classified into two groups. The one is a group containing 149 individuals which consist of some homozygous and some heterozygous longs or intermediates, and the other is a group containing 59 individuals which consist of only homozygous shorts.

When we calculate the deviation and the mean error from these numbers assuming them to make a 3:1 ratio respectively we have the following table:

TABLE XXXIX.

Assumed type	Observed Absolute	Observed per 4	Expected per 4	Deviation Obs.-Expect	m_4
Mixed long	149	2.87	3.00	−0.13	±0.12
Homo. short	59	1.12	1.00	+0.13	±0.12
Total	208	4.00	4.00	0.00	

Seeing the results of the calculation we can think appropriately *that the 26 intermediates of the F_2-generation have, in the present* generation, segregated in the ratio as we assumed.

C. CONCLUSION AND DISCUSSION.

From the above mentioned results of the experiments on seed-length we can draw the conclusion as follows:

1. The seed-length of *Sesamum indicum* are definite to their own types and they are each displayed by one set of genes.
2. The length of the hybrid between short and long parents is almost intermediate but tends a little to long and it segregates into 3:1 ratio or 1:2:1 after the simple Mendelian rule.

Next let us take the seed-breadth and examine the hereditary nature of the character. We see in Tables XXXII-B and -C that the seed-breadth of I-type is 22.47 and the variability of the character is 5.79% on the average for 4 years. When we compare the variability to that of the length the former is much larger than that of the latter as is seen in Table XXXII-C. We see also in the same table that the correlation between the breadth and the length is 0.48± 0.02 toward positive, so that in this case a certain correlation in these two factors may exist though not a very significant one.

Also we see in Tables XXXIV-B and -C that the breadth of II-type is 21.03 and the variability of that character is 6.23% on the average of the four years. When we compare the variability to that of the length, the former is much larger than that of the latter as is seen in Table XXXVI-C. We see in the same table that the correlation between the breadth and the length of II-type is −0.08± 0.02, so that in this case almost any correlation between these two factors can not be seen although the coefficient is not zero.

We see in Table XXXVI-C that the correlation coefficient between the length and the breadth of seeds in the F_1-generation of $I \times II$-hybrid is 0.34 ± 0.02 which shows the correlation can not be considered a significant one. It is, however, worth while to note that the correlation coefficient of the hybrid is somewhat intermediate between those of the parents.

As is stated above the correlations between the length and the breadth in all cases are not significant and this shows that the one of the two factors can not be taken as an index in any way of the other. This is due to the greater variability of the breadth. Why, then, the breadth is so variable independently of the length is worth while to consider.

The absolute length of seeds depends on the diameter of the capsule in which the seeds have been growing and the breadth of seeds depends on the number of cells of the capsule.

The capsule of I-type is invariably 4-celled while that of II-type is 6-celled or 8-celled or sometimes 10-celled even in normal growth of the capsule as is shown in Pl. V, Figs. 13, 14—17; so that the length and the breadth of seeds of I-type may nearly be constant or in other words, there may exist some correlation between them, but the relation of breadth to length of II-type is very variable as the correlation coefficient shows it. Thus in this case if we should take one of the two dimensions separately to see the hereditary behavior, we would have the length only, as this dimension is more stable than the other.

Size or shape is usually displayed by more than one factor or by multiple factors, so that if a size of same object be studied by genetical analysis, the segregation would sometimes be very complicated, and very often the original types are not restored in F_2-generation unless the number of individuals of that generation be considerably large as is suggested by EMERSON and EAST (1912). This is why the mode of inheritance of such kind was once thought to be a distinct type of inheritance known as "Blending" as CASTLE (1921) write in his book. He writes also as follows:

".........but at present we are inclined to give them a different explanation, the same in fact as for ordinary Mendelian inheritance except that several factors, instead of one, are supposed to be concerned in the case, and that dominance is not in evidence."

So that if one factor be concerned in a character the segregation

would be observed very simply as in the case of Tall and Short of pea-plants as MENDEL got the start of others or in the case of man's brachydactylism studied by FARABEE etc. as CASTLE quotes.

So in the case of seed-length of my sesame the character is displayed by one gene and consequently the hereditary behavior is very simple and this shows that a size or shape may be studied genetically after the Mendelian fashion if the character be analyzed to its factor or factors. Some authors, however, seem to think that in cases of quantitative characters the factors or genes concerned are many, but I think some of such characters are manifested by only a few factors, but as the characters tend to be affected very easily by environmental conditions the analysis is difficult and it seems to be composed of many factors or genes.

XIV. Color of the Seed-coat.

Although the seeds of I-, II- and III-type display white, black and brown color respectively, they are equally colorless when they are in an early stage of development. As the seeds, however, attain the maturity they display their proper colors and become very conspicuous so as to be designated by the colors. For such a reason we see every grade of the color between the two extremes, when we examine the seeds in an immature stage even in a single capsule; then we must distinguish the seed-colors in the consideration of the ages when we want to classify them properly.

Thus I-type has white color in an ordinary sense of the word, but the whiteness is due to the presence of crystals of calcium oxalate in the epidermis, then it will be appropriate to designate the seeds as colorless or pale pinkish buff or pale pinkish cinnamon or pale cinnamon pink as they are really so tinged. The last mentioned three colors are of course different, but they are very much alike as we find them in the same "f-series" in Pl. XXX of "Color Standard and Color Nomenclature" (RIDGWAY, l. c.). Although the seed-color of I-type should be of one among them a fluctuation makes it very difficult to determine it so I took provisionally "Pale Pinkish Buff" as we see it more frequently than others. II-type has black color and III-type has brown or more appropriately "Cinnamon Buff" by the Color Standard but the latter color sometimes is noticed to come out with a little fluctuation by the degrees of maturity and dryness

etc. of the seed.

Seed-coat is generally derived from one or two integuments of the ovule, but in some cases part of nucellus or even part of endosperm is added when no integument is developed as, for instance, in the case of *Crinum* (RENDLE, 1904). In the case of *Sesamum indicum* a single integument is developed and when the latter matures it forms the seed-coat of this plant.

When we make sections of the seed-coat of this plant and examine the structure we see two layers (o and i in Pl. X, Fig. 46-A) which form the seed-coat (S), in the outermost and underneath or in the inner place lies a layer of several cells which form the endosperm (E) as is shown in the same figure.

As can be seen in Pl. X, Fig. 46-A, the two layers (o and i) of I-type have no color so that the seed is really colorless as is already stated, but the presence of mealy substance due to the deposit of calcium oxalate in the outer layer makes it look actually white.

The two layers of the seed-coat of II-type corresponding to those of I-type are much different from those of the latter. In the first place the outer layer (o) of this type has no mealy substance but in about the outer half of the wall of each cell black pigment or fragment of protoplasm having a dark color are deposited as is shown in Pl. X, Figs. 47-A, o; 47-B, and the inner half of the wall is not only thickened but also it is tinged with "Massicot Yellow" as is shown in the same plate, Figs. 47-A, o and 47-C. The inner layer (i) of the seed-coat of this type is very slightly tinged with buff or yellow color which, however, almost takes no part in making the color of the seed-coat. The blackness of this seed-coat is then due to the presence of the black pigments in the outer part of the epidermal cells, for the massicot yellow if present, on the thickened part of the same cells is mechanically hidden under the black pigments, the inner layer (i) almost not taking any part in making the seed-coat color. In such a case we may call the blackness as mechanically epistatic to massicot in comparison with the case of the color of mice (BATESON, 1913).

In the seed-coat of III-type about the outer half of the epidermal cell wall is tinged with "Cream Buff' and the thickened part of the same is also tinged with the same color as is shown in the same plate-figures (Pl. X, Figs. 48-A, o; 48-B, 48-C). The inner layer (i)

of this seed-coat is very slightly tinged with buff or yellow color, but this color does not take any part in making up the seed-coat color as that of II-type. Then the color of the seed-coat of this type is due to the presence of "Cream Buff" pigment in the epidermis, perhaps in cooperation with the color of the thickened part of the same cells.

The above mentioned three types are used in the investigation of seed-colors.

(1) EXPERIMENTS WITH I- AND II-TYPE.

As the color of the seed-coat is so conspicuous that it is taken as a distinctive character of the varieties some investigators paid much attention to the character and some of them tried to analyse it genetically but it was not an easy matter though it seemed to be, because the color was much affected by the degrees of maturity and dryness, etc. of the seeds even when they were produced in one and the same capsule.

In my investigation the genetic analysis of the character was felt to be the most difficult one, but repeated experiments have reached the certain results which will be described in the following pages.

A. FIRST SERIES OF I- AND II-type.

F_1-GENERATION. The black is dominant over the white or more precisely colorlessness, and the dominancy is perfect without the crystals of calcium oxalate which, if present, may veil and conceal the true color of the seed, so that the seeds of this generation are quite identical with that of the black parent or II-type.

The manifestation of this black color is on the same histological basis with that of the black seed of II-type as the microscopical examination shows.

F_2-GENERATION. The seeds of this generation come out with varieties of several different colors. They were identified by the "Color Standard and Color Nomenclature" as follows: (1) Black, (2) Cinnamon, (3) Cinnamon Buff, (4) Avellaneous, (5) Pinkish Buff, (6) Light Buff, (7) Light Pinkish Cinnamon, (8) Tilleul Buff, (9) Pale Pinkish Buff and (10) White.

As is said above the degrees of maturity and dryness of seeds cause the diversity in the colors of seeds, not only in the colors themselves but also in tints or shades largely due to the presence or absence of the crystals of calcium oxalate. When a black seed, for instance, has crystals the whole appearance is Dark Neutral Gray, that is to say, the black is veiled and somewhat whitened or when a seed of Pale Pinkish Buff is covered by the same substance it looks white in the same reason.

From this fact an accurate determination of seed colors should be done after the removal of such substance. Removing the crystals, therefore, is an important matter for a certain distinction of the genuine seed colors but it is impossible to remove the crystals, so I thought to see the inner color through the crystals without being interfered by such substance and then I tried to make them transparnt. For this purpose I soaked the seeds having the crystals in acetic acid, alcohol, chloroform, clove oil, ether, and xylol to let them penetrate into the seeds for about 36 hours. Alcohol seems to be the most favorable for this purpose as it penetrates into the materials in a few hours while all the others do not do so as fast as alcohol.

For a few kinds or a small quantity of materials, however, this method might be applied practically but it is not possible for so many kinds or a large quantity as to be used in F_2 or the population of later generations for distinction. So it was possible to distinguish them only by inspection.

In these considerations I classified the colors mentioned before into four groups by means of identification with the "Color Standard and Color Noménclature." In identifying the colors of the seeds with those of the Standard the tints and shades besides the colors themselves were taken into consideration but as to the origin of colors in the Standard whether it may be pure full spectrum colors or not was not considered because the origin of light has no concern with the identification. There might be some other way but I classified the colors into four groups as a clue of analysis as follows:

1 st, Black group contains only black, with crystals or without them, and the pedigree Nos. 1, 4, 5, 9, 11, 12, 14, 16, 17, 20, 23, 24, 25, 26, 29, 32, 34, 36, 38, 40 and 41 are contained in this group. This group, therefore, contains 21 individuals.

2nd, Dark Brown group contains Cinnamon, Cinnamon Buff,

Avellaneous, Light Pinkish Cinnamon, Pinkish Buff, with or without crystals, and the pedigree Nos. 7, 8, 10, 15, 19 and 39 are contained in this group. This group therfore contains 6 individuals.

3rd, Pale Brown group contains Light Buff, Tilleul Buff, Pale Pinkish Cinnamon and Pale Pinkish Buff, with or without crystals, and the pedigree Nos. belonging to this group are 2, 6, 13, 18, 21, 30, 31, 33 and 35, being 9 individuals in all.

4th, White group contains white only with crystals and the pedigree Nos. belonging to this group are 3, 22, 27, 28 and 37, being 5 individuals in all.

Although the above mentioned four groups are thus established the classification is quite arbitrary because the tone of a series of each color is not only graduated with a slight difference but also a spectrum series is graduated in the same way. As the Black is, however, more distinct and stable than any other, this color may be taken as the first index of the ratio, and next the white may be taken as the second, but the latter is really colorless or very slightly tinged.

Very pale color as Light Buff, Tilleul Buff, Pale Pinkish Cinnamon or Pale Pinkish Buff belonging to the 3rd group or even Pinkish Buff belonging to the 2nd group may be more appropriately classified into the 4th, because if the seeds having pale colors be endowed with the crystals look white, or conversely some members of the 4th group might be classified appropriately into the 3rd or the 2nd as they are masked by the crystals.

We must bear in mind, however, that the seeds having the crystals do not necessarily belong to the 4th group because if seeds having colored ground are endowed with crystals they do not look white and then they may come under the 1st or 2nd or even the 3rd group.

Now when we arrange the numbers of the above mentioned four groups in the order of darkness we obtain the following:

Black		Dark Brown		Pale Brown		White
21	:	6	:	9	:	5

If we assume that the F_1-Black segregates into four groups in F_2-generation and there is not any linkage between the genes and the combination of genes will be carried on in equal chance, the observed number will make 9:3:3:1 ratio respectively. But of these assumptions the combination of genes in equal chance is hardly

expected, especially so when the total number of individuals is small as in the present case; so that let us provisionally suppose them to have segregated into 9:3:3:1 ratio and calculate the deviations and mean errors in order to see the relation between the observed number.

First let us take the number of the Black group as an index of the ratio and compare with the sum of the latter three terms together as making 9:7 ratio respectively, then the results of calculation are as follows:

TABLE XL.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. obs. expect.	m_{16}
Blacks	21	8.20	9.	−0.80	±1.24
Non-blacks	20	7.80	7.	+0.80	±1.24
Total	41	16.00	16.	0.00	

In the Table XL we see that the deviation is ±0.80 and the mean error is ±1.24, that is the former is much smaller than the latter, so that we may think that the assumed ratio, 9:7, may be appropriately taken as true for segregation.

Next let us take the first three groups together as the colored class and compare with the 4th group or colorless one and calculate the ratio, then we obtain the following:

TABLE XLI.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. obs. expect.	m_{16}
Colored	36	14.05	15.	−0.95	±0.60
Non-colored	5	1.95	1.	+0.95	±0.60
Total	41	16.00	16.	0.00	

As is shown in the Table XLI the deviation seems to be pretty large, but as the results of calculation show it is still smaller than twice the mean error so that the segregation may be taken as it had been carried on in 15:1 ratio as was assumed.

Again let us take the middle two terms together and assume them to have segregated into 9: 6: 1 ratio and calculate the deviations and the mean errors, then we obtain the following:

TABLE XLII.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. obs. expect.	m_{16}
1st or black g.	21	8.20	9.	−0.80	±1.24
2nd g.+3rd g.	15	5.85	6.	−0.15	±1.21
4th g.	5	1.95	1.	+0.95	±0.60
Total	41	16.00	16.	0.00	

As is shown in the Table XLII the results of calculation show that each deviation is less at most twice the corresponding mean error, so that the segregation may be taken as it had been carried on as the assumed ratio.

Finally let us assume the four groups to have segregated into 9:3:3:1 ratio and calculate the deviations and mean errors, then we obtain the following:

TABLE XLIII.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. obs. expect.	m_{16}
1st group	21	8.20	9.	−0.80	±1.24
2nd group	6	2.34	3.	−0.66	±0.98
3rd group	9	3.51	3.	+0.51	±0.98
4th group	5	1.95	1.	+0.95	±0.60
Total	41	16.00	16.	0.00	

We see in the Table XLIII that all the deviations are smaller than twice their own mean error, so that we may think appropriately that the segregation has taken place in the assumed ratio.

All the above mentioned results show that the segregation of the observed number, 41, has taken place in the ratio of 9:3:3:1, but as the total number is too small to be relied on, so that it will

be safer not to determine the segregation ratio and the nature of characters of genes until the examination of other series has been completed. However, it is almost clear that the colored group is not 63 times as large as the 4th group or colorless one, still less if we take three individuals, the Tilleul Buff 1, the Pale Pinkish Buff 2, which are almost colorless from the 3rd group and add them to the 4th group, the ratio of colored against colorless would not make 63 : 1 respectively or they do not make 3 : 1 ratio.

From these facts we may think that the character is manifested by two essential gene difference and we may proceed further in this assumption.

F_3–GENERATION. From the colored F_2-individuals some of the Blacks were proved to be homozygous and some others to be heterozygous and to produce the progenies of different colors ranging from Black to White according to the genetic compositions of the individuals, still some of the Non-Blacks but colored F_2-individuals were proved to be homozygous and some others to be heterozygous and to produce the progenies of different colors from their own color down to White in heterozygous individuals.

The White F_2-individuals are always homozygous and they have invariably crystals, but had we taken Light Buff, Tilleul Buff, Pale Pinkish Cinnamon and Pale Pinkish Buff without crystals as White and classify them into the 4th group, they might have produced the progenies, in F_3-generation, having some Pale color like their parent or might be White with crystals, because the seeds lacking crystals may be heterozygous or homozygous as the presence of the substance is recessive as we know. The above mentioned facts were known by raising the F_3-generation but unfortunately some seeds of the F_2-individuals did not germinate or F_3-plants have died or they could not produce enough of seeds to be relied upon for investigation, so that the determination must be postponed until the examination of other series has been completed.

B. SECOND SERIES OF I- AND II-TYPE.

F_1-GENERATION. Black color is perfectly dominant over the White as in the first series and it segregates in the second generation.

F_2-GENERATION. In this generation 60 individuals were cropped and there appeared several varieties of colors as in the case of the

first series but a few colors newly appeared in this series.

Classifying them into four groups in the same way as in the first series we obtained the following:

1st group or Black:
 Black 30
2nd group or Dark Brown:
 Saccado's Umber 2
 Verona Brown 8
 Tawny Olive. 4
 Clay Color 2
 Pinkish Buff 10
3rd group or Pale Brown : 0
4th group or White:
 White 4

If we take the Black group vs. all the others together and see the ratio, it is quite 30:30 or 1:1, but if we assume the F_1 to be a dihybrid and it segregated after simple Mendelian rule without any linkage among genes, the ratio, would be thought very likely to be 9:7 respectively as in the case of the first series.

When we calculate the deviations and mean errors based on the assumption we obtain the following:

TABLE XLIV.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. obs. expect.	m_{16}
Black	30	8.00	9.	−1.00	±1.02
Non-Black	30	8.00	7.	+1.00	±1.02
Total	60	16.00	16.	0.00	

From the Table XLIV we see that the deviation is a little smaller than the mean error, so that we may think the segregation has taken place in the 9:7 ratio as we assumed. If we take the 1st, 2nd and 3rd groups together, 56 in number, as the colored group vs. 4th, 4 in number as the non-colored one and calculate the deviation and mean error on the assumption of making 15:1 ratio we obtain the following:

TABLE XLV.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. obs. expect.	m_{16}
Colored	56	14.93	15.	−0.07	±0.50
Non-colored or white	4	1.07	1.	+0.07	±0.50
Total	60	16.00	16.	0.00	

As we see in Table XLV the deviations are much smaller than those corresponding mean errors, so that the segregation can appropriately be supposed to have been carried on in the 9:7 ratio as we assumed.

Of the above mentioned four groups the 3rd has no member but Pinkish Buff in the 2nd, 10 in number, might correspond to one of the 3rd group of the 1st series because such intermediate colors are sometimes changeable according to the environmental conditions so that if we shift these individuals to the 3rd group, the four groups will become as follows:

Black		Dark Brown		Pale Brown		White
30	:	16	:	10	:	4

When we calculate the deviations and the corresponding mean errors assuming to make 9:3:3:1 ratio, we obtain the following:

TABLE XLVI.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. obs. expect.	m_{16}
1st group	30	8.00	9.	−1.00	±1.02
2nd group	16	4.26	3.	+1.26	±0.81
3rd group	10	2.67	3.	−0.33	±0.81
4th group	4	1.06	1.	+0.07	±0.50
Total	60	16.00	16.	0.00	

As is seen in Table XLVI assuming them to be the true nature of segregation, the results of calculation show that the deviations of the 1st, 3rd and 4th groups are more or less smaller than their corresponding mean errors and the deviation of the 2nd group is much smaller than twice its mean error so that we may take them to have segregated into 9:3:3:1 ratio as we assumed. But in

treating such smaller number of individuals we must not put much weight upon the smallness of deviations and it will be felt too wilful to shift the Pinkish Buff into the 3rd group. However it is supposed that the essential genes concerning the characters are neither more nor less than two pairs, in short the character is expressed by two-gene difference.

From these facts I am inclined to express the genetic composition of Black color as $B_1B_1B_2B_2$ and the White Color as $b_1b_1b_2b_2$, the B_1 standing for the gene of Dark Brown color and B_2 for the gene of Pale Brown color so that their allelomorphs, b_1 and b_2 are standing for the genes of colorlessness.

The gene B_1 may be complex of a number of small genes but it can be supposed to be an essential gene for producing Dark Brown color, and the gene B_2 may also be a complex of a number of some small genes for producing Pale Brown color. Moreover the genes, B_1 and B_2, seem to manifest the Black color acting as something like complementary genes with each other when they meet in one zygote, but when they remain solely they manifest their own character.

Assuming thus we can formulate the genetic compositions of F_1 and F_2 individuals as following:

TABLE XLVII.

Checkerboard analysis of theoretical expectations of Blacks in F_2.

$B_1B_1B_2B_2$ .... $b_1b_1b_2b_2$ .... P

$B_1b_1B_2b_2$ .... F_1

The individuals of F_2

♀ \ ♂	B_1B_2	B_1b_2	b_1B_2	b_1b_2
B_1B_2	$B_1B_1B_2B_2$	$B_1B_1B_2b_2$	$B_1b_1B_2B_2$	$B_1b_1B_2b_2$
B_1b_2	$B_1B_1B_2b_2$	$B_1B_1b_2b_2$	$B_1b_1B_2b_2$	$B_1b_1b_2b_2$
b_1B_2	$B_1b_1B_2B_2$	$B_1b_1B_2b_2$	$b_1b_1B_2B_2$	$b_1b_1B_2b_2$
b_1b_2	$B_1b_1B_2b_2$	$B_1b_1b_2b_2$	$b_1b_1B_2b_2$	$b_1b_1b_2b_2$

As we see in the checkerboard figure there are 9 Blacks, 3 Dark Browns, 3 Pale Browns and 1 White per 16 individuals, and if we assort them by the colors, but assuming B_1 and B_2 to be in the complementary situation to manifest Black color, the assumptions of

the ratio hitherto done can easily be explained.

F_3-GENERATION. Progenies of 60 F_2-individuals were raised and some individuals of their families were obtained. Of those families let us take the F_2-Blacks only and examine them by their progenies.

The crops of those Blacks are as follows:

TABLE XLVIII.

F_2	F_3				Probable compositions of F_2-individuals
Pedig. Nos.	1st group	2nd group	3rd group	4th group	
3	8	0	2	0	$B_1b_1B_2B_2$
4	11	2	0	2	$B_1b_1B_2b_2$
9	2	1	1	1	$B_1b_1B_2b_2$
10	3	1	2	0	$B_1b_1B_2b_2$
14	8	0	3	0	$B_1b_1B_2B_2$
17	6	0	1	0	$B_1b_1B_2B_2$
18	4	0	1	0	$B_1b_1B_2B_2$
19	10	2	2	0	$B_1b_1B_2b_2$
22	7	2	2	1	$B_1b_1B_2b_2$
25	12	0	0	0	$B_1B_1B_2B_2$
27	9	1	4	0	$B_1b_1B_2b_2$
29	7	1	0	0	$B_1B_1B_2b_2$
31	10	0	0	2	$B_1b_1B_2b_2$
33	10	0	0	0	$B_1B_1B_2B_2$
34	2	0	1	0	$B_1b_1B_2B_2$
35	9	2	4	0	$B_1b_1B_2b_2$
36	9	4	8	0	$B_1b_1B_2b_2$
37	7	3	2	3	$B_1b_1B_2b_2$
38	15	0	0	0	$B_1B_1B_2B_2$
40	5	3	0	0	$B_1B_1B_2b_2$
41	3	0	2	0	$B_1b_1B_2B_2$
44	11	0	5	0	$B_1b_1B_2B_2$
45	7	4	0	0	$B_1B_1B_2b_2$
50	1	3	3	2	$B_1b_1B_2b_2$
51	1	3	2	0	$B_1b_1B_2b_2$
52	12	3	0	0	$B_1B_1B_2b_2$
53	10	2	1	1	$B_1b_1B_2b_2$
54	10	6	0	0	$B_1B_1B_2b_2$
56	4	1	3	1	$B_1b_1B_2b_2$
60	6	3	0	0	$B_1B_1B_2b_2$

The progenies of F_2-families are not enough to warrant the compositions of F_2-Blacks, yet the feature of segregation and consequently the genetical nature can roughly be seen from Table XLVII.

As a rule we expect to have, out of 9 F_2-Blacks, 1 Black which produces all Blacks in its F_3, 2 Blacks which segregate into Black and Dark Brown in 3 : 1 , 2 Blacks which segregate into Black and Pale Brown in 3 : 1 ratio and 4 Blacks which segregate into Black, DarkBrown, Pale Brown and White in 9 : 3 : 3 : 1 ratio respectively, then we may expect to have the above mentioned 4 kinds of F_2 from 30 Blacks in the following ratio and mode:

TABLE XLIX.

Expectation out of 9 Blacks in F_2	Expectation out of 30 Blacks in F_2	Expected segregation in F_3			
		Blacks	Dark Brown	Pale Brown	White
1	3.33	all	0	0	0
2	6.67	3	1	0	0
2	6.67	3	0	1	0
4	13.33	9	3	3	1

It is not easy to decide the ratio of segregation exactly based on the F_3-individuals of the Table XLVIII, yet we know that the segregation of F_2 Black-families will be carried on as in the Table XLIX, so that if we have some members under the heading of the "4th group" only, we may think that their parents would correspond to the last of the 9 : 3 : 3 : 1 ratio, and if we have some members under the heading of the "1st group" only, in the same ratio, we may think that the parents would be a homozygous Black.

In such inference, when we assort the progenies of F_2-families and formulate the compositions of the families therefrom, we shall have the factorial compositions as shown in the last column of the Table XLVIII. As the results of the assortment in such a fashion, among those 30 F_2-individuals we have 3 homozygous Blacks consisting of pedigree Nos. 25, 33 and 38; 6 F_2-Blacks which segregate into 3 Blacks to 1 Dark Brown consisting of pedigree Nos. 29, 40, 45, 52, 54 and 60; 7 F_2-Blacks which segregate into 3 Blacks to 1 Pale Brown consisting of pedigree Nos. 3, 14, 17, 18, 34, 41, 44; and 14 F_2-Blacks which segregate into 9 : 3 : 3 : 1 ratio, consisting of pedigree Nos. 4, 9, 10, 19, 22, 27, 31, 35, 36, 37, 50, 51, 53 and 56.

The number of F_2-generation thus formulated is nearly the same with the expectation out of 30 Blacks in Table XLIX; and if we put together the F_3-individuals of the same category, we obtain the following:

TABLE L.

F_2		$B_1B_1B_2B_2$	$B_1B_1B_2b_2$	$B_1b_1B_2B_2$	$B_1b_1B_2b_2$
F_3	1st	37	47	42	93
	2nd	0	20	0	27
	3rd	0	0	15	34
	4th	0	0	0	13

As we see in the Table L the individuals of the F_3-generation do not make gross deviations from the expectation, so that the assortment may be said to have been done appropriately.

C. THIRD SERIES OF I- AND II-TYPE.

F_1-GENERATION. Black color is perfect dominant over White as in the preceding series and the character segregates in the F_2-generation.

F_2-GENERATION. We obtained 65 individuals in this generation and there appeared several colors as in the preceding series, and assorting them in the same methods we obtain the following:

1st group or Black group	34
2nd+3rd+4th groups	31
Total	65

If we take them to make 9:7 ratio we have ± 0.63 for the deviation and ± 0.98 for the mean error, so that the ratio can be taken as true as the deviation being due to the mere chance of random sampling.

F_3-GENERATION. I raised F_3-individuals, and among them if we decide the nature of F_2-Blacks by their progenies, we obtain 7 homozygous and 27 heterozygous Blacks.

In examining the 27 heterozygous Blacks we distinguished 7 Blackswhich have the composition of $B_1B_1B_2b_2$ segregating into the ratio of 3 Blacks to 1 Dark Brown, 7 Blacks which have the composition of $B_1b_1B_2B_2$ segregating into the ratio of 3 Blacks and 1 Pale Brown, 16 Blacks which have the composition of $B_1b_1B_2b_2$

segregating intoBlack, Dark Brown, Pale Brown, White in the ratio of 9:3:3:1 respectively.

There are not enough of the F_3-individuals to agree with the expectation but assuming the F_1 is dihybrid having the composition of $B_1b_1B_2b_2$ as in the second series and calculating the F_2-Blacks, we should expect to have 3.78 of homozygous Blacks, 7.56 of heterozygous Blacks which will segregate into 3 Blacks vs. 1 Dark Brown, 7.56 of heterozygous Blacks which will segregate into 3 Blacks vs. 1 Pale Brown and 15.10 of heterozygous Blacks which will segregate into 9 Blacks, 3 Dark Browns, 3 Pale Browns and 1 White per 16.

The expectation is almost realized as in the case of the second series, so that the assumption that the F_1 is dihybrid having the composition of $B_1b_1B_2b_2$, is very likly to be established.

D. Fourth Series of I- and II-type.

F_1-GENERATION. Black color is perfect dominant over White and it segregates into several colors in the second generation as in the preceding series.

F_2-GENERATION. In this generation I cropped 96 individuals and in examining them I saw several different colors among them, so I classified in the same way as before and I obtained the following:

1st group or Black group	53
2nd + 3rd + 4th groups	43
Total	96

If we assume them to be in 9:7 ratio per 16 and calculate we have ± 0.17 for the deviation and ± 0.81 for its mean error, so that the assumption may be said to be true, but the F_3-generation was not raised.

From the results of the above mentioned experiments, it is almost clear that the number of Blacks to all others make the ratio of 9:7 per 16, though sometimes 8:8 ratio may be taken as true. The appearance of such an inconsistent phenomenon may be worth of consideration, but I am inclined to think that it is due to the insufficient amount of individuals in the experiments, and when we sum up all the results according to the same categories and see the ratio, we obtain the following table.

TABLE LI.

Series of I and II-type	1st group or Blacks	2nd group or Dark Browns	3rd group or Pale Browns	4th group or Whites	Total
first	21	6	8	5	41
second	30	16	10*	4	60
third	34	14	9	8	65
fourth	53	22	16	5	96
Total	138	58	44	22	262

* The number, 10 in the second series of the table, having an asterisk has sometimes been included in the 2nd group or Dark Brown group, but the individuals have somewhat paler color, so that I shifted them to the 3rd group. Otherwise here we have not any member of the 3rd group and this is too strange depending on the mere chance of random sampling, provided there is no linkage.

Assuming that the F_1's have segregated into 9:3:3:1 ratio in their F_2-generations, and calculating the deviations and the mean errors, we have the results as the following table:

TABLE LII.

Assumed types	Observation		Expectation	Deviation	Mean error
	absolute	per 16	per 16	diff. betw. O. E.	m_{16}
Black	138	8.43	9.	−0.57	±0.49
Dark-brown	58	3.54	3.	+0.54	±0.39
Pale-brown	44	2.69	3.	−0.31	±0.39
White	22	1.34	1.	+0.34	±0.24

From the Table LII, I am much inclined to think that the character in question is displayed by the two-gene difference and the segregation of the genes is to be carried out without any linkage among them. The results of back-crossings are examined as follows.

E. BACK-CROSSING.

I crossed back I-type to F_1 of the hybrids between I- and II-type in 1928, 1929 and 1931, and obtained 275 individuals in all.

In examining them were found such forms having new colors as Slate Black, Deep Neutral Gray, Dark Neutral Gray, Neutral Gray and Mouse Gray which are to be grouped into the 1st group

with Black; Verona Brown, Mikado Brown, Sayal Brown and Snuff Brown which are to be grouped into the 2nd; Pale Ochraceous Buff which is to be grouped into the 3rd. Thus they were classified as follows:

TABLE LIII.

Year	1st group	2nd group	3rd group	4th group	Total
1928	13	14	5	10	42
1929	18	32	28	30	108
1931	34	30	31	30	125
Total	65	76	64	70	275

When we assume the character is displayed by two-gene difference as was supposed and there is no linkage among the genes, we should, in the results, expect to have the four groups in the ratio of 1 : 1 : 1 : 1, and when we calculate the individuals upon these assumptions we obtain the following:

TABLE LIV.

Group	Observation		Expectation	Deviation	Mean error
	absolute	per 4	per 4	Obs. -Expect.	m_4
1 st	65	0.94	1.	−0.06	±0.10
2 nd	76	1.11	1.	+0.11	±0.10
3 rd	64	0.93	1.	−0.07	±0.10
4 th	70	1.02	1.	+0.02	±0.10
Total	275	4.00	4.	0.00	

As we see in Table LIV all the deviations, excepting that of the nd group, are smaller than their corresponding mean errors, and the eviation of the 2nd group is much smaller than twice its mean rror, so that the assumption that the observed numbers are very kely to have segregated in the ratio of 1 : 1 : 1 : 1 per 4, seems o be realized.

F. CONCLUSION OF (1).

Concerning the genetical behavior of the color of *Sesamum*

seed-coat very little is known. Only ABE (1919) experimented a little with the same material and concluded that the factors concerning the colors will be two pairs, or the characters of Black and White will perhaps be displayed by the two-factor difference.

Recently TESHIMA (1931) made public the results of his experiments in colors of *Sesamum* seeds. First he experimented with the Black and White, and obtained Black seeds in F_1 as well as about 20 intermediate colors between the Black and White in F_2-generation. In F_3-population he classified the individuals into 16 colors besides Black and White. Based on the numbers of the individuals obtained in his experiments, he seems to think the colors, Black and White, to be displayed by the three-gene difference.

Secondly he experimented with Yellow, Brown, and Yellowish Brown besides White and Black, and obtained 17 categories of different colors, but he did not decide what the genes were displaying colors.

The investigation of colors of this plant is not so easy as it was supposed to be. The visible color is, in reality, not only masked by the crystal of calcium oxalate but also the ages of seeds conceal the true nature of color as HOWARDS and KHAN write in their memoirs, "the full development of color of the seed coat appears to be a question of development".

As has already been mentioned, FRUWIRTH states in his book that there are such kinds as those producing black and whitish seed, dark-brown and smoky grey seeds occurring on one plant.

There is not such a plant, however, which produces any mosaic seeds. The fact can be proved by sowing such seeds separately, but on the contrary it has been proved not to be correct and this was due to the question of development or the grade of maturity of seeds as HOWARDS and others write (HOWARD, 1919).

In my experiments I endeavoured to remove such obstacles and to find the real nature of colors. As far as my experiments went, the blackness was perfect dominant over the whiteness. This whiteness, however, is not the real color of the seed-coat in this case, or in other words, the whiteness is due to the presence of crystals on the wall which has not any pigment but very pale Light Buff or something like that, just as the earth looks white when the ground even of ocher color is covered with snow or hail. So that strictly speaking, the blackness is dominant over the colorlessness or possibly over very pale Light Buff color.

The results of my experiments reveal that there are two pairs of genes concerning the essential colors of seed-coats of I- and II-type and the genes for Blackness is $B_1B_1B_2B_2$ and those of Whiteness $b_1b_1b_2b_2$ as was already formulated.

By the essential color is meant color-complex indirectly, the minor colors being those of the wall color of the half thickened part of the epidermal cells in II-type or the similar seeds and the color of the outer wall of the epidermal cells etc; but as there are many impediments to interfere with each other it is very hard to separate and determine them definitely. This is the reason, I think, why so many colors appear in F_2-generation.

Sometimes in my experiments the results of calculation of the 3rd group did not agree with the expectation, but when we put them together with the 3rd group and the 2nd or with the 3rd group and the 4th we have seen the expectation fulfilled. This is very likely to be due to the incorrect assortment of the individuals, for the members of the 3rd group have sometimes very pale Light Buff or sometimes deeper Light Buff and they are taken for White or Brown as the case may be.

In my experiments I assure that the Black is the highest in potency, then follow the Dark Brown, the Pale Brown and the White, the White being the lowest, so that the Black, for instance, gives Blacks and the lower other colors; while the White does not give off any other color but White itself.

I experienced that when White seeds mixed with Black, Gray and Neutral Gray were sown, the White gave off Black as well as the lower several colors, In this case the White seeds had not been really white but appeared to be so, as they were immature in the seed coat while the embryos were perfect. FRUWIRTH's statement that there are kinds which produce the black and whitish seed, dark-brown and smoky gray seeds occurring in one plant might correspond to such immature seeds as I quoted above; and that the F_2-White gave off Black to White in F_3-generation in TESHIMA'S second table is supposed to be of the same cause, otherwise the fact that the recessive White is to give off the dominant Black must be explained in an other way (TESHIMA, 1931).

TESHIMA's information seems not to have touched the question of the crystals and it is not known what kind of materials he used. If he had used the same materials as I did and had taken the cry-

stals consciously or unconsciously as a cause of colors, there might have been three pairs of essential genes for the colors.

Under these considerations I venture to say that the colors of I- and II-types are displayed by two essential genic differences.

(2) EXPERIMENTS WITH II- AND III-TYPE.

As is known the seed color of II-type is Black and that of III-type is Cinnamon Buff, and as the seeds of both types do not have crystals of calcium oxalate their apparent colors are genuine and accordingly the distinction of colors is more simple in this respect than in the case of the preceding experiments, but Black and Russet are sometimes apt to be mistaken as they resemble with each other when the seeds are immature.

A. ORDINARY CROSSING.

F_1-GENERATION. I crossed ♂III to ♀II-type for many years and the color of the seeds thus obtained were of the same all the time. The seed color of this generation is Black and as both parents have no crystal in seeds, of course the F_1-seeds have no crystal too, then the seeds of this generation is quite similar to those of II-type, so that the Black is perfect dominant over the Cinnamon Buff.

I crossed the types reciprocally to the above one for many years also, and obtained the same results all the time, and all the seeds of this generation were of the same in color as that of the direct crosses, that is the Black is perfect dominant over the Cinnamon Buff.

F_2-GENERATION. The heterozygous F_1-black segregates into several colors but the ESSENTIAL COLORS are distinguished from the others with only the trouble of immature seeds but without the interference by crystals and they were classified into 4 groups as 1st group, containing Black, 2nd group, containing Russet, 3rd group, containing Avellaneous and 4th group, containing Cinnamon Buff. The results of the reciprocal crossing have been of the same, so that the results of both experiments may be taken together and calculate them in order to see the genetic behaviors.

Thus the results of the two experiments taken together are as follows:

TABLE LV.

Crossing, Generation	Year	1st, Black	2nd, Russet	3rd, Avellaneous	4th, Cinnamon Buff	Total
II×III-F_2	1925	16	6	4	2	28
	1926	97	29	29	11	166
	1929	100	13	38	11	162
	1930	236	53	66	20	375
III×II-F_2	1925	12	3	3	0	18
	1926	99	32	30	11	172
	1929	96	16	35	17	164
	1930	244	55	77	30	406
	Total	900	207	282	102	1491

Let us assume them to have segregated into 9:3:3:1 ratio and calculate them to see what the deviations and the mean errors are, then we obtain the following:

TABLE LVI.

Group	Observation		Expectation	Deviation	Mean error
	Absolute	per 16	per 16	Obs.-Expect.	m_{16}
1st, Black	900	9.66	9.	+0.66	±0.21
2nd, Russet	207	2.22	3.	−0.78	±0.16
3rd, Avellaneous	282	3.03	3.	+0.03	±0.16
4th, Cinnamon Buff	102	1.09	1.	−0.09	±0.10
Total	1491	16.00	16.	0.00	

In the Table LVI we see that the deviations in the 1st and the 2nd groups are a little too large against the mean errors although the deviations in the 3rd and the 4th groups are smaller than the mean errors. But let us take these groups in two parts putting together the 1st and the 2nd for one part, and the 3rd and the 4th for the other, and calculate them as making 12:4 ratio, then we obtain the following:

TABLE LVII.

Part	Observation		Expectation	Deviation	Mean error
	Absolute	per 16	per 16	Obs.-Expect.	m_{16}
I	1107	11.88	12.	−0.12	±0.18
II	384	4.16	4.	+0.12	±0.18
Total	1491	16.00	16.	0.00	

In the Table LVII we can infer that the Black and Russet together against the Avellaneous and Cinnamon Buff together make 12:4 ratio as far as the calculation is concerned, then it is supposed that the distinction of the individuals in the 1st and the 2nd groups in the Table LV is not done correctly.

Let us then examine the results of the back-crossing and see how the gametes are formed.

B. BACK-CROSSING.

I made a back-crosssing, for three years, mating III-type which is recessive in color to the one of the F_1-individuals obtained between II- and III-type, and obtained the following results:

TABLE LVIII.

Year	Black	Russet	Avellaneous	Cinnamon Buff	Total
1928	10	7	5	9	31
1929	16	10	14	8	48
1931	37	49	41	49	176
Total	63	66	60	66	255

From the results shown in Table LVIII we can infer that the recombination of genes has been carried on in free assortment, and the fact can be seen from the following table:

TABLE LIX.

Group	Observation		Expectation	Deviation	Mean error
	Absolute	per 4	per 4	Observ.-Expect.	m_4
1st, Black	63	0.98	1.	−0.02	±0.11
2nd, Russet	66	1.04	1.	+0.04	±0.11
3rd, Avellaneous	60	0.94	1.	−0.06	±0.11
4th, Cinnamon	66	1.04	1.	+0.04	±0.11
Total	255	4.00	4.	0.00	

From the results shown in Table LIX it is very likely to be supposed that the segregation and recombination shown in Table LVI must have been carried on in the 9:3:3:1 ratio, but that the numbers of each group do not exactly agree with the expectation is due to the incorrect distinction between the 1st and the 2nd group as was already inferred.

C. CONCLUSION OF (2).

From the above mentioned results I think I am able to draw the conclusion that the Black is perfectly dominant over Cinnamon Buff and the allelomorphic characters are displayed by the two-gene difference.

The genes of F_1-individuals segregate without any linkage and recombine in free assortment in F_2-generation where the zygotes appear in four classes of colors as Black, Russet, Avellaneous and Cinnamon Buff.

When we want to formulate the genetic compositions of the parental plants as regard to the characters in question, the II-type of Black color will be expressed as $B_3B_3B_4B_4$ and the III-type of Cinnamon Buff against Black will be expressed as $b_3b_3b_4b_4$. Consequently the zygotes of F_1-generation is expressed as $B_3b_3B_4b_4$ and the compositions of the individuals of later generations will be identical with some of F_2, and the later generation of the hybridizations with II- and III-type and the corresponding results will be obtained under the same assumptions on the relation between I- and II-type.

(3) EXPERIMENTS WITH I- AND III-TYPE.

Of the two types the I-type has crystals in the seed-coat but the III-type has none. The relation between I- and III-type is the same as that between the I- and the II-type in this respect.

A. ORDINARY CROSSING.

F_1-GENERATION. Crops of individuals of this generation were secured several times and the character was always of the same in direct and reciprocal crossings. Thus the color of the seed-coat of this generation was Cinnamon Buff without crystals so that the seeds of this generation were quite similar to those of III-type which reveal the dominancy of Cinnamon Buff over the White or Colorless.

F_2-GENERATION. The individuals of F_1-generation segregate and reappear in several forms of color in the present generation. They have been classified into 1st group containing Cinnamon Buff, 2nd group containing Pinkish Buff, 3rd group containing Pale Ochraceous Buff and 4th group containing White.

As the feature of the reciprocal crossing is the same with that of the direct one, the results in the two cases may be taken together as one and the results are as follows:

TABLE LX.

Generation and Year	1st group or Cinnamon Buff	2nd group or Pinkish Buff	3rd group or Pale Ochr. B.	4th group or White	Total
III×I-F_2 in 1926	74	41	27	4	146
I×III-F_2 in 1929	58	18	12	10	98
Total	132	59	39	14	244

If we assume them to have segregated in four classes in the ratio of 9:3:3:1 and calculate deviations and mean errors, we obtain the following:

TABLE LXI.

Assumed types	Observation Absolute	Observation per 16	Expectation per 16	Deviation Observ.-Expect.	Mean error m_{16}
1st or Cinn. B.	132	8.65	9.	−0.35	±0.25
2nd or Pink. B.	59	3.87	3.	+0.87	±0.40
3rd or P. O. B.	39	2.56	3.	−0.44	±0.40
4th or White	14	0.92	1.	+0.08	±0.25
Total	244	16.00	16.	0.00	

From the Table LXI it may be inferred that the segregation has been carried on according to the assumption.

B. BACK-CROSSING.

I raised some individuals produced by mating I-type to some of the F_1-individuals which had been produced by the cross between I- and III-type. The back-crossing was repeated for three years, 1928, 1929, 1931, and the summarized results are as follows:

TABLE LXII.

Year	Cinnamon Buff	Pinkish Buff	Pale Ochraceous Buff	White	Total
1928	35	28	31	19	113
1929	23	38	20	36	117
1931	35	35	41	41	152
Total	93	101	92	96	382

From the results shown in Table LXII it can be guessed that the recombination of genes has been carried on in free assortment, the fact of which can be seen from the following table:

TABLE LXIII.

Group	Observation Absolulte	Observation per 4	Expectation per 4	Deviation Observ.-Expect.	Mean error m_4
1st group, Cinnam. B.	93	0.97	1.	−0.03	±0.09
2nd group, Pink. B.	101	1.06	1.	+0.06	±0.09
3rd group, Pale Och.B.	92	0.96	1.	−0.04	±0.09
4th group, White	96	1.01	1.	+0.01	±0.09
Fotal	382	4.00	4.	0.	

From the results shown in Table LXIII it is very likely to be supposed that the segregation and recombination shown in Table LX must have been carried on in 9:3:3:1 ratio, but that the numbers of each group are not exactly coincident with the expectation is due to the incorrect distinction of the phenotypes.

C. Conclusion of (3).

From the above mentioned experimental results we can come to the conclusion that the Cinnamon Buff is perfectly dominant over the White and the character is displayed by the two-gene difference. The genes of F_1-individuals segregate and recombine freely in F_2 so that the four classes of color system appear phenotypically.

When we want to form the genetic compositions of the parental plants as regard to the character in question, the III-type of Cinnamon Buff will be expressed as $C_1C_1C_2C_2$ and the I-type of White against Cinnamon Buff will be expressed as $c_1c_1c_2c_2$. Then the zygotes of F_1-generation will be expressed as $C_1c_1C_2c_2$, and the compositions of the individuals of F_2 and the later generations can easily be obtained as in the case of the hybridizations with I- and II-type or with II- and III-type, and the corresponding results will be obtained under the same assumption.

(4) Summary and Discussion on Colors of Seed-coat.

When Black is crossed to White, directly or reciprocally, the F_1's have black seeds similar to those of II-type and they segregate into several forms of color in F_2, but in assorting them we obtain four essential colors as Black, Dark Brown, Pale Brown and White.

The F_2-individuals make approximately 9:3:3:1 ratio of these essential colors from which we may think that they are displayed by the two-gene difference. Among these colors the Black is the highest and the White the lowest in potency making a series in the order arranged above.

When Black is crossed to Cinnamon Buff, directly or reciprocally, the F_1's have black seeds similar to those of II-type and they segregate into several forms of color in F_2. In assorting the F_2-individuals by the essential colors, Black, Russet, Avellaneous

Cinnamon Buff, we obtain a 9 : 3 : 3 : 1 ratio approximately from the facts of which we may think that the color is displayed by the two-gene difference.

The Black is the highest and the Cinnamon Buff is the lowest in potency, and they make a series in the order arranged above.

When Cinnamon Buff is crossed to White, either directly or reciprocally, the F_1's have Cinnamon Buff seeds similar to those of III-type and they segregate into several forms of color in F_2. In assorting them by the essential colors, Cinnamon Buff, Pinkish Buff, Pale Ochraceous Buff and White, we obtain a 9 : 3 : 3 : 1 ratio approximately from the fact of which we may think that the color is displayed by the two-gene difference. The four colors make a series of potency in the order arranged above.

The highest color, Black, for instance, is sometimes observed to pass every grade of colors in its course from White up to its own color in the immature capsule, so that when such a capsule is cropped, various seeds are to be seen. When white seeds from such a capsule are sown, however, black seeds are obtainable. Such phenomena are observed in other types and they are sometimes mistaken to be true, that is because various kinds of color occur in one and the same capsule as FRUWIRTH states.

The arguments as to the color-complex mentioned under the section of I- and II-type are to be applied to all other cases, so that I shall not repeat them again.

XV. Deposit, Cell-wall, Diaphragm in epidermal Cells of the Seed-coat.

When we look at the surface of the seeds of I-type through a low magnifying glass we can easily see a white mealy substance almost evenly scattered all over the surface excepting a marginal line of somewhat flattened seeds. In sections this is found to be due to the deposition of some substance having the shape of sphaerocrystal in the inner side of the outer wall of epidermal cells (Pl. X, Figs. 46-A, 46-B,; Pl. VII, Figs. 37-A, 37-B). This substance seems to have radial fissures and the air is filled in them, so that the air refracts the light and gives the substance the appearance of the white meal. According to WITTMACK (1922) the substance

is the crystal of calcium oxalate as is already quoted.

Along with the difference of presence and absence of such substance a more striking difference in the seed-coat can be observed. When we make sections of the seed-coats of three types and examine them more closely the difference can easily be detected. As is shown in Pl. X, Fig. 46-A, 47-A and 48-A, the cell wall of the pallisade tissue of epidermis in I-type remains unchanged even when it became old with an exception of having been endowed with the sphaero-crystals of calcium oxalate inside the outer wall as has already been stated; on the other hand the cells of the corresponding tissue of II- and III-type have their side wall thickened almost half lower part of each cell just as seen in the so called "Stäbchenschicht" (WITTMACK, p. 286) under the epidermis of *Sinapis* (*Brassica*) *juncea* or *Cicer arietinum* and *Melanosinapis nigra* etc. in TSCHIRCH's work (TSCHIRCH, 1889). Not only are the side walls thus thickened but also the bottom walls of the same cells are provided with crystal-like substance growing centripetally on the walls to some extent as is shown in Pl. X, Figs. 47-C, 48-C; Pl. VII, Fig. 38-C; Pl. VIII, Fig. 39-C, and I named the substance "diaphragm" provisionally. The extent of the diaphragms is variable, i. e., the substance in some cells is well developed, while in others the development is very poor.

From the above mentioned statement we see that, when the seed-coat has deposit of calcium oxalate, its cell wall is not thickened and also has no diaphragm; in other words, the presence and absence of the deposit of the crystals in the epidermal cells have the reverse sequence in the thickening of walls as well as the formation of the diaphragm.

I-type has deposit of calcium oxalate and consequently no thickening and diaphragm, while II- and III-type have not deposit but thickening and diaphragm. The relation of these characters is shown in the following table:

TABLE LXIV.

	Deposition	Diaphragm	Thickened wall
I-type	×	0	0
II-type	0	×	×
III-type	0	×	×

The cross mark represents positive and the small circle negative.

These characters are entirely associated to form the complete linkage when we assume the characters are displayed each by one pair of genes. So that the genetic behavior of one character, say deposition, can decide the character behavior of the remaining two, say diaphragm and the thickening, in this case. As the examination of the character is more easily done in the deposition of calcium oxalate than in others, we might take the character, deposition, for investigations.

(1) EXPERIMENTS WITH I- AND II-TYPE.

A. ORDINARY CROSSING.

F_1-GENERATION. All the hybrids between I- and II-type have no deposition quite similar to the seeds of II-type, so that the absence of this substance is perfect dominant over the presence of the same.

F_2-GENERATION. The individuals of this generation came out in two forms one of which has the deposition and the other has none, so that it is evident that in this character a segregation has taken place and what is the genetical behavior of the character or genes is perceived from the results shown in the following table:

TABLE LXV.

	Plants having no deposition	Plants having deposition	Total
First series	32	9	41
Second series	44	16	60
Third series	49	16	65
Fourth series	69	27	96
Total	194	68	262

The number of plants having the dominant character in each series or in the totals is almost exactly three times larger than that of the recessive plants. This suggests that the character is displayed by one-gene difference and that it is segregated after the simple Mendelian rule.

F_3-GENERATION. I have raised F_3-plants from those tabulated series separately but I take up the third series in order to show the

behavior of the later generation, as this series, as we see in the table, has the dominant plants and the recessive ones in an exact 3:1 ratio respectively. There are 49 dominant or non-deposited plants and 16 recessive or deposited ones in F_2-generation of this series.

In raising F_3-plants the recessive 16 plants (A-class in Table LXVI) have produced the progenies, all having the deposition as might be expected to have. Among the 49 non-deposited plants, 23 (B-class + C-class) have produced their progenies having no deposition at all, and the others, 26 (D-class) in number, have segregated into dominant and recessive type revealing they are *heterozygous*.

Judging merely from the results we might classify the F_2-individuals into: Homo. dom. 23, Hetero. dom. 26, Rec. 16, to make 1:2:1 ratio. But the result is very far from the expectation so that we come to think that there might be some reason for the disagreement.

Now let us tabulate the results and consider these non-deposited or dominant typed F_2-plants and their progenies.

Supposing there is such a plant of F_2-generation as produced one dominant type and one recessive one, we should take this F_2-plant as a heterozygous one. This shows positively the fact as it segregated even in so small a number, but if there is such one as produced 4 or 5 progenies whose nature is all dominant we should hesitate to justify the F_2-plant to be homozygous dominant as the number is too small. If there were more progenies there would be some possibility to have some recessive progenies with those dominant ones. *In such a consideration I ventured to omit the* F_2-plants (C-class) which produced the progenies of small number.

Thus when taking up B-class, D-class and A-class from the table *and arrange the numbers in this order we obtain the following:*

Homo. dominant		Hetero. dominant		Recessive
14	:	26	:	16

The ratio of these individuals is nearly 1:2:1 but the heterozygous dominant is a little too small in number for the others.

Next let us examine the progenies of the heterozygous dominant of D-class. The non-deposited type is 149 and the deposited one is 59 as is seen in the table. The ratio of these individuals is expected to be 3:1 but the deposited type is a little larger than the other. From those foregoing two ratios we can suppose that some

TABLE LXVI.

A-class (Recessive in F_2)

F_2-pedig. Nos. of Recessive.	F_3-plants Non-depos.	Depos.
4	0	5
5	0	11
8	0	10
9	0	7
20	0	6
23	0	4
27	0	4
35	0	4
39	0	9
41	0	14
45	0	4
48	0	4
49	0	5
55	0	5
60	0	4
63	0	9
Total, 16	0	105

B-class (Homo. dominant in F_2)

F_2-pedig. Nos. of Homo. Dom.	F_3-plants Non-depos.	Depos.
13	3	0
15	14	0
16	8	0
17	11	0
18	13	0
19	9	0
22	11	0
26	9	0
30	12	0
31	11	0
36	9	0
50	10	0
51	11	0
54	13	0
Total, 14	154	0

C-class (omitted)

F_2-pedig. Nos. of doubtful Homo. Dom.	F_3-plants Non-depos.	Deposit
10	5	0
28	6	0
29	4	0
33	6	0
34	6	0
40	5	0
53	6	0
64	6	0
65	6	0
Total, 9	50	0

D-class (Hetero. dominant in F_2)

F_2-pedig. Nos. of Dominant	F_3-plants Non-depos.	Deposit
1	10	4
2	7	7
3	6	1
6	11	3
7	6	3
11	5	3
12	5	2
14	8	1
21	4	1
24	3	1
25	3	1
32	3	1
37	3	1
38	11	2
42	5	1
43	9	2
44	9	3
46	8	1
47	3	2
52	11	3
56	3	2
57	2	3
58	2	2
59	7	4
61	3	2
62	2	3
Total, 26	149	59

F_2-members of C-class should be classified in D-class, in other words, those members are really heterozygous dominants which could not display their true nature, for the progenies are not many enough as I presupposed, hence the members of C-class being omitted.

If a few members of C-class be transferred with their progenies into D-class and calculated, the ratio would come out nearly to the expected one. From this fact the omitting of the members of C-class can be said to have been appropriately done. It is too much to add more for such a simple matter, but some other data in the same line are prepared which may be allowed to mention here.

B. Results of back-crossings.

Back-crossings between F_1 of I × II and I-type have been carried on for three years and the results so far obtained will be tabulated below:

TABLE LXVII.

Character / Year	Non-deposited or dominants	Deposited or recessives	Total
1928	20	22	42
1929	58	50	108
1931	64	61	125
Total	142	133	275

Depositing character is recessive and it is carried by I-type, so that the ratio of dominants vs. recessives is expected to be 1:1 as the results. The ratio obtained in each year and consequently that of the totals of these three years come out to be nearly in the expected ratio as is seen in Table LXVII.

(2) Experiments with I- and III-type.

Experiments on the same character were performed between I- and III-type and the results will be mentioned here.

A. Ordinary crossing.

F_1-GENERATION. All the hybrids have no deposition similar to

the seeds of III-type irrespective of any one has been used as the pollen parent, so that non-deposited is dominant to deposited as in the case with I- vs. II-type.

F_2-GENERATION. In this generation the hybrids come out in two types, one of which is non-deposited like III-type and the other deposited like I-type. The results of the experiments obtained in 1926 and 1929 will be tabulated below:

TABLE LXVIII.

Year	*The way of hybridization*	*Non-deposited or dominant type*	*Deposited or recessive type*	Total
1626	III×I-F_2	110	36	146
1929	I×III-F_2	72	26	98
Total		182	62	244

In this table the result of I×III-F_2 is taken together with that of its reciprocal, III×I-F_2, as the feature is quite similar in both cases as is mentioned before.

In the table we see that the dominant typed individuals vs. recessive typed ones make the ratio of 3:1 almost exactly. It can be known, from this result, that the character is also manifested by one-gene difference and a segregation in F_2 has been carried on very simply after the Mendelian rule.

B. RESULTS OF BACK-CROSSING.

Back-crossings between F_1 of I×III and I-type have been carried on for three years and the results will be shown in the following table:

TABLE LXIX.

Year \ Characters	Non-deposited or dominants	Deposited or recessives	Total
1928	55	58	113
1929	56	61	117
1931	76	76	152
Total	187	195	382

We see in the table that the ratio of dominants vs. recessives in each year and consequently in three years together is almost exactly 1 : 1 as might be expected.

(3) Conclusion and Discussion.

All the above mentioned results with respect to the characters in question point to the same conclusion as in the following:

1. The deposition of crystals of calcium oxalate on the inner side of the wall of I-type forms a pair of allelomorphs with its non-deposition of II-type, and the former is recessive to the latter.
2. The character pair is manifested by one-gene difference and the F_1-individuals segregates in F_2-generation into dominants and recessives in the ratio of 3 : 1, behaving after the simple Mendelian rule.
3. The character of "diaphragm" is manifested by the same gene which concerns the expression of the character of thickening the epidermal cells, i. e., the case might be said to be one of the manifold manifestations of a single gene, as is shown in Table LXIV.
4. The above mentioned characters of I-type vs. those of III-type holds the same relation with those of I-type vs. II-type.

Abe (1919) and Howards and Khan (1919) have investigated the characters of the same plant but they seem not to have touched upon any of these characters in question. Of many characters of the plant the depositing of the crystals of calcium oxalate is a remarkable thing not only in having the deposition itself, but also the character has many relations to other characters.

XVI. Roughness and Smoothness of Seed-coat.

The surface of some seed-coats is rough while that of some others is smooth, and this character is sometimes very conspicuous when the surface of such seeds is seen under a low magnifying glass. This is one of the definite characteristics to certain varieties and in fact, the seeds of I-type have smooth coat and those of II-type have rough one while those of III-type have somewhat intermediate character as can be seen in Pl. VII, Figs. 37-A, 38-A; Pl. VIII, Fig. 39-A. The surface of the seed-coat is made rough either by the occurrence of fine projections on the surface or by the unevenness due to the irregularity in the length of epidermal cells or by the

co-existence of these two elements at the same time. (Pl. X, Figs. 46-A, 47-A, 48-A)

When there is an irregularity in the length of epidermal cells only, the surface of such a seed-coat looks as if the coat has minute wrinkles caused by shrinkage. For this reason we should investigate the character in question from the two sides separately although the result is the same.

The roughness of the seed-coat of II-type is chiefly caused by the unevenness due to the irregular depressions of the surface, so that when this type is used in hybridization to I-type which has smooth surface in the seed-coat, the treatment is simple excepting the trouble of distinguishing the phenotypes in the progeny which might be interfered by the presence of the crystals of calcium oxalate, but when I-type is hybridized to III-type the roughness of which is chiefly caused by the presence of fine projections on the surface of the seed-coat the treatment is not so simple, then the roughness should be considered from two sides separately.

Now let us use provisionally the word "wrinkle" for the phenotypical appearance of the seeds of II-type, though it is not really the cause or causes of the roughness.

(1) Results of Experiments with I- and II-type.

A. Second series, cropped in 1924.

F_1-GENERATION. The individuals of this generation have almost smooth seeds-coat or very slightly wrinkled.

F_2-GENERATION. The individuals of this generation appeared in two different types: the one has smooth surface and the other has wrinkled one. In classifying the population of this generation 48 non-wrinkled and 12 wrinkled individuals were obtained, so that it is supposed that the characters are displayed by one-gene difference and have segregated after the simple Mendelian rule.

Now assuming these F_2-individuals to have segregated in 3:1 ratio, F_3-individuals were raised. In examining the progenies it was found that the 48 non-wrinkled individuals consist of 20 homozygous individuals and 28 heterozygous ones, and that the 12 wrinkled in F_2 bred true. These numbers make 1:2:1 ratio though not exact, but they approach the ratio nearer than any other providing that the population in F_2 have segregated after the Mendelian rule.

B. Third series, cropped in 1925.

F_1-GENERATION. The individuals of this generation have no wrinkles or slightly wrinkled as in the case of the second series.

F_2-GENERATION. The individuals of this generation appeared in two different types as in the case of the preceding series and 50 non-wrinkled and 15 wrinkled were classified among 65 individuals.

From the characters of the progeny of these 65 individuals, it was found that these 50 non-wrinkled individuals consist of 21 homozygous and 29 heterozygous ones. The numbers of these classes, 21 homozygous non-wrinkled, 29 heterozygous non-wrinkled and 15 wrinkled, point to the ratio of 1:2:1 respectively.

If we calculate, by way of experiment, the ratio of the results of the foregoing two series taking together and assuming them to have segregated in 3:1 ratio, we obtain $\pm$ 0.14 for the deviation and $\pm$0.15 for the mean error, so that the segregation may be said to have carried on aswe assumed.

(2) Results of Experiments with II- and III-type.

A. Wrinkledness and non-wrinkledness.

F_1-GENERATION. The individuals of this generation have almost no wrinkle without regard to which one is used as egg-parent or as pollen-parent.

F_2-GENERATION. In this generation two different types have appeared, the one having wrinkles and the other none, and in assorting them the following results were obtained:

TABLE LXX.

	Year	Non-wrinkled	Wrinkled	Total
II×III-F_2	1925 1929 1930	23 124 287	5 38 88	28 162 375
	Total	434	131	565
III×II-F_2	1925 1929 1930	9 121 324	9 43 82	18 164 406
	Total	454	134	588
Reciprocals	Totals	888	265	1153

In each assortment in the table it seems that the numbers of non-wrinkled vs. wrinkled make approximate ratio of 3:1 respectively. For trial calculation based on the totals of the above table, we obtain ± 0.08 for deviation and ± 0.05 for its mean error assuming them to have segregated in the ratio 3:1. The deviation is smaller than twice the mean error so that the assumption might be taken as true.

From the results we see that the non-wrinkled is almost perfect dominant to the wrinkled, and the heterozygous individuals segregate the characters after the simple Mendelian rule.

B. PROJECTIONED AND NON-PROJECTIONED.

F_1-GENERATION. The individuals of this generation came out having no projections or very slightly with them, irrespective of which was used as egg-parent or pollen-parent.

F_2-GENERATION. The individuals appeared in two types, one having projections and the other none. In assorting them we obtained the results shown in the following table:

TABLE LXXI.

	Year	Non-projetioned	Projectioned	Total
II×III-F_2	1925	21	7	28
	1929	116	46	162
	1930	260	115	375
	Total	397	168	565
III×II-F_2	1925	14	4	18
	1929	122	42	164
	1930	304	102	406
	Total	440	146	588
Reciprocals	Totals	837	316	1153

As we see in the above table each of the total numbers of a single cross seems to be of 3:1 ratio and assuming them to make that ratio of segregation when we calculate the total numbers of the reciprocals based on the above mentioned results, we obtain *± 0.10 for the deviation and ± 0.05 for the mean error.*

The results of the calculation show that the deviation is only

twice as large as the mean error, so that we may think that the characters are expressed by one-gene difference and segregate after the simple Mendelian rule.

C. Test of dihybrids.

When we combine these two pairs of characters as dihybrid and classify them phenotypically in the F_2-generation, assuming the genes of the characters to be borne on the different chromosomes and to make free combination, we obtain nearly 9:3:3:1 ratio as the result of each year. The records of the results obtained in these years are kept, but here I will take one of these instances which appeared in Table LXXII.

In classifying the results of the table we obtain the following:

NW	NP	90	Non-wrinkled and having no projection.
	p	31	Non-wrinkled having projections.
w	NP	32	Wrinkled and having no projection.
	p	11	Wrinkled and having projections.
Totals		164	

The roughness is caused by the presence of one or both of the wrinkles and projections, and the smoothness must be attributed to the lack of both the wrinkles and the projections at a time, so that 9 smooth seeds out of 16 and 7 rough seeds out of 16 in proportion are expected to be present, and this was realized though it has not been expressed yet.

If we denote the smoothness due to the non-wrinkledness as I_1I_1, meaning the inhibition of wrinkling, and the smoothness due to the non-projection as I_2I_2, meaning the inhibition of projection, the genetic composition of II-type will be expressed in $i_1i_1I_2I_2$ and that of III-type in $I_1I_1i_2i_2$ while that of F_1 in $I_1i_1I_2i_2$. In this case, if the capital letter represents the dominancy to the recessiveness of the corresponding small letter, the individuals of F_2-generation will be obtained and classified as the Table LXXII.

Conclusion and Discussion.

From the above mentioned results we can draw the following conclusions:

TABLE LXXII.

Results of III×II-F_2.

Pedig. Nos.	NW.	w.	NP.	p.	Pedig. Nos.	NW.	w.	NP.	p.	Pedig. Nos.	NW.	w.	NP.	p.	Pedig. Nos.	NW.	w.	NP.	p.
1	×		×		43		×	×		85	×		×		127	×			×
2	×		×		44	×		×		86	×		×		128		×		×
3		×	×		45	×		×		87	×		×		129	×			×
4		×	×		46		×	×		88	×			×	130	×		×	
5	×		×		47	×		×		89	×		×		131	×		×	
6	×		×		48	×			×	90		×		×	132	×		×	
7		×	×		49	×		×		91	×		×		133	×		×	
8	×		×		50		×	×		92	×		×		134	×		×	
9	×		×		51	×		×		93	×		×		135		×		×
10	×		×		52	×		×		94	×			×	136	×		×	
11	×		×		53	×		×		95		×	×		137		×		×
12		×	×		54		×	×		96	×		×		138	×		×	
13	×		×		55	×		×		97		×	×		139		×		×
14	×		×		56	×		×		98		×		×	140	×		×	
15	×		×		57	×		×		99	×		×		141	×		×	
16		×	×		58		×	×		100	×		×		142	×		×	
17		×	×		59		×	×		101	×			×	143		×	×	
18	×		×		60	×		×		102		×	×		144	×			×
19		×	×		61	×			×	103	×			×	145	×		×	
20	×		×		62	×			×	104	×			×	146	×		×	
21		×	×		63	×		×		105	×			×	147		×		×
22	×		×		64		×	×		106	×		×		148	×			×
23		×	×		65	×		×		107	×			×	149	×			×
24	×		×		66	×			×	108	×			×	150	×		×	
25	×		×		67		×	×		109	×		×		151	×		×	
26	×		×		68	×		×		110	×		×		152		×	×	
27	×		×		69	×		×		111		×		×	153		×	×	
28	×			×	70	×		×		112	×			×	154		×	×	
29	×		×		71	×		×		113	×			×	155	×			×
30		×	×		72	×		×		114		×		×	156	×		×	
31	×		×		73	×		×		115	×		×		157		×	×	
32	×		×		74		×	×		116	×		×		158		×	×	
33	×		×		75		×		×	117		×		×	159	×		×	
34	×		×		76	×		×		118	×		×		160	×			×
35		×	×		77	×			×	119	×		×		161	×		×	
36	×		×		78	×			×	120	×		×		162		×	×	
37	×		×		79	×			×	121	×			×	163	×			×
38	×		×		80	×		×		122		×	×		164	×			×
39	×		×		81	×			×	123	×			×					
40	×		×		82	×			×	124	×		×						
41	×		×		83	×		×		125		×	×						
42	×		×		84	×		×		126	×		×		Totals	121	43	122	42

The results of classifying the F_2-population of the hybrid between III-type and II-type *concerning wrinkledness and having projections* and their *reverse*. In the headings of the table NW denotes the non-wrinkled, w the wrinkled, NP denotes the non-projectioned and p the projectioned.

1. The roughness is caused by the presence either of wrinkles or projections or both on the surface of the seed-coat. The smoothness is therefore due to the absence of both causes.

2. The absence of wrinkles and projections is almost completely dominant to the reverse and accordingly the smoothness of the seed-coat is almost completely dominant to the roughness of the same.

3. The wrinkledness and projections each of which makes its allelomorphic pair with its reverse, and the pair segregates after the simple Mendelian rule.

The statement concerning the characters of the seed-coat of this plant has not been found in any other literature excepting that of HOWARDS and KHAN (1919). Their statements suggest that the smoothness is dominant to roughness as we recognized, but they seem not to have investigated the characters more genetically. They state that no homozygotes with rough seeds were isolated, however I think if they had continued their experiments pure homozygotes with smooth seed might have been isolated. I myself began with rough seeds of II-type which is pure in regard to the character in question.

Here we must be cautious in treatment as to the roughness which comes from two sides when we use the seeds of II- vs. III-type. Here I may add a few words about the disagreement of the observed numbers with the expected ratio. In genetical investigation of the characters in the hybrids and their progeny, we see that the characters caused by those genes sometimes do not develop well, so it makes hard or sometimes impossible to distinguish the characters caused by the activity of the different genes; moreover, when the crystals in the epidermal cells of the seeds are developed as in that of I-type the seeds are always smooth, in other words, the characters in question may be interfered mechanically with the presence of the crystals which makes the true nature of the seed-coat indistinguishable. This is possibly the cause or causes of the disagreement.

XVII. Quality and Quantity of Oil in the Seeds.

The seeds of sesame contain not only the oily sustance but also abundant albuminous substance, calcium compounds and phosphoric compounds. These substances are said to be very nutritious, and to obtain them is one of the chief purposes of the cultivation of this plant. According to VON TOCHER the sesame-oil contains the so-called

"sesamin" having a chemical composition of $C_{18}H_{18}O_5$ which seems to be an essence of this oil (CZAPEK, 1921).

It was my first aim to see how much the oily substance or the substance with other ingredients is contained and then to see the hereditary behavior in the quantity of oil, so that it is necessary to obtain the materials of a pure line in JOHANNSEN's sense.

It is impossible, however, to test the quantity of oil in the seeds to be sown but we know as JENNINGS (1916–1917) and some others have calculated, that the proportion of homozygous individuals to all the population including heterozygous ones come to about 99.99 % at the 15th generation if we propagate a plant with an allelomorphic pair of a character by continued self-fertilization, so that if the allelomorphic pair be expressed in AA and aa the chances of extracting either AA or aa will be 49.99 times out of 50.00 or 4999 times out of 5000.

In my experiment the generations in this way have come to over the 15th in continued self-fertilization, so that it is very probable that I might extract the one or the other of the two homozygous forms for one type of sesame in regard to the character in question. There may be some fear of extracting the same character for both I- and II-type fortuitously, that is AA or aa for both types as their genes.

No matter, however, what we extract we could decide it as the contents of the seeds as such, and in this situation the seeds were analyzed and obtained the following results:

TABLE LXXIII.

Substances \ Plant-types	I-type	II-type	Averages of 2 types
Water	6.55	6.56	6.56 –
Crude protein	22.72	23.52	23.12
Crude oil	47.42	42.81	44.87 –
Carbohydrates and ashes etc.	23.31	27.61	25.46
Total	100.00	100.00	100.00

Previous to my analysis, YOSHIMURA (1921) analyzed the black seed of *Sesamum* and he obtained the following results:

TABLE LXXIV.

	Black seeds
Water	8.570
Crude protein	22.088
Crude oil	44.560
Carbohydrates and ashes etc.[1]	24.782
Total	100.000

The material used for his analysis is, as he states, of black seeds perhaps identical with my II-type and he secured it from some seed dealers in that locality. We see that the results of YOSHIMURA's analysis do not make much difference from those of mine which refer to II-type.

Next I analyzed the seeds of the hybrids and the results so far obtained are as follows:

TABLE LXXV.

Substances \ Plant-types	I×II-F_1	II×I-F_1	Averages of 2 hybrids
Water	6.41	6.36	6.39−
Crude protein	22.53	24.51	23.52
Crude oil	47.40	41.67	44.54−
Carbohydrates and ashes etc.	23.66	27.46	25.56
Total	100.00	100.00	100.00

In this analysis Mr. KURAHASI, one of my colleagues of the Mito Kôtô-Gakkô, gave me much help and here I express my hearty thanks for his kindness of having done so much for me. He used the SOXHLET's method for the extraction of oil and KJELDAHL's method for the determination of protein.

In Tables LXXIII and LXXV we see that the quantities of the protein, the oily substances and accordingly the carbohydrates and ashes etc. in the seeds of I×II-F_1 and the reciprocal hybrid resemble those of the mother plants, i.e., it appears to be a case of maternal inheritance in a broader sense of the word, although the behavior

[1] Dr. YOSHIMURA analyzed the carbohydrates and the others minutely, but I put them together to compare them with mine.

of their descendants is not yet known.

Before explaining the above mentioned phenomenon we should consider, first of all, the structure of the seeds and the proportions or percentages expressed in the tables. The essential parts from which these substances are obtained are the endosperm as well as the embryo, and in the case of these hybrids the endosperm and the embryo are parts of the F_1-plants but the seed-coats are parts of P-plants. The quantities tabulated here, therefore, are the percentages proportioned to these two plant bodies belonging to different generations and not the percentages from real F_1-plants, or in other words, they are drawn from the mixture of the parts of both F_1- and P-plants.

It is inferred from the structure of the seed-coat that the seed-coat of II-type is much more voluminous and heavier than that of I-type as has already been stated, and when I weighed 500 seeds of each type I obtained 1.305 gr. for I-type and 1.035 gr. for II-type; that is to say, the weight of one seed grain in both types is nearly the same. Then the endosperm and the embryo of I-type should be heavier than those of II-type. Taking these things into consideration we can conclude that the protein and the oily substances of the seed having the tender and thinner seed-coat like I-type are greater in proportion than those of the seeds having the stiff and heavier seed-coat like II-type, no matter what generations the parts belong to; and the appearance of the matroclinous nature in these substances can perhaps be accounted for in the relativity of the weight of the seed-coat to that of the embryo together with the endosperm; and if the quantities of these substances contained in the embryos only be treated, the hereditary behavior would have followed a simple Mendelian rule.

XVIII. Earliness and Lateness.

As has already been stated a form having an early ripening character has been added to my investigation later, and the general characters of this form have already be given too. Many of the characters of this form very much resemble those of II-type and really this is identical with the latter type in having black seeds but early ripening character to other forms is singular.

For the investigation of this character this form has been used

as the material.

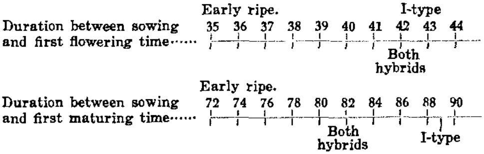
F_1-GENERATION. Growing of F_1-plants was undertaken in 1930 and 1931, but in the year 1931 we could not crop the F_1-plants in good condition for the seeds were sown under a big tree and the seedlings were not only too much sheltered but also beaten and washed off by heavy rain. Some crops obtained in 1930, however, are available and we may express the results in a table together with the feature of the parents for the purpose of comparison.

TABLE LXXVI.

Crops from seeds sown in June 17, 1930.

	First flowering period		First maturity of fruits	
	Date	Duration between sowing and flowering	Date	Duration between sowing and maturity
I-type	July 30	43 days	Sept. 14	89 days
Early ripe.	July 22	35 days	Aug. 28	72 days
I×Early-F_1	July 29	42 days	Sept. 7	82 days
Early×I-F_1	July 29	42 days	Sept. 7	82 days

From the table we see that the plants of this generation bloom and attain the maturity of the fruits between the days of their parents, but rather nearing the later flowering variety, and the feature can be expressed by the scaled lines shown below.



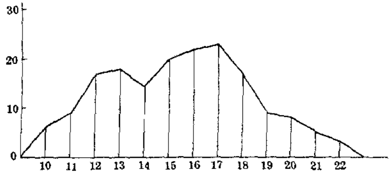
F_2-GENERATION. The plants of this generation have been raised in 1931 from the hybrid between early ripening variety and I-type. The seeds from which the plants sprung had been sown on the 18th of June. The date is, therefore, one day later than that of the preceding year. The plants were fortunately cropped well this year, but in comparing those of the parents or F_1-plants, we should bear in mind that the conditions in the different years (1930 and 1931) are hardly the same, especially in 1931 we had often heavy rain while the weather in 1930 was moderately well.

As the frequency table LXXVII shows, the flowering began on Aug. 10th and it lasted till Aug. 22nd, and the crop of this generation has began on Sept. 16th and it lasted till the 3rd of October. This shows that the growth has been delayed by the more unfavorable conditions than in the preceding year, so that the periods of the flowering and maturity of fruits may be improper to compare with the other directly and though it is very hard to compensate for the loss caused by the unfavorable conditions yet the feature of hereditary behavior of the characters may be seen from the table.

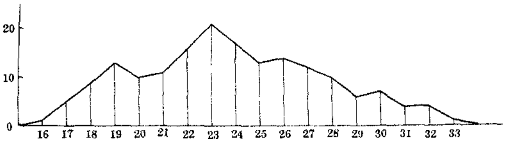
TABLE LXXVII.

Early ripening variety × I-type F_2 cropped in 1931.

		Fruit ripening period																		
Month		September															October			
Date		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	Total
Flowering period August	10	1	2	2	1															6
	11		2	2	2	1	1	1												9
	12		1	2	3	3	2	2	2	1		1								17
	13			2	2	2	3	3	2	1	1	1	1							18
	14			1	2	1	1	2	3	3	2	1	1							17
	15				2	2	2	3	4	2	1	2	1	1						20
	16				1	1	1	2	2	4	3	2	3	2	1					22
	17						1	2	5	4	3	3	1	2	1	1				23
	18							1	2	2	2	2	2	2	1	1	1		1	17
	19								1		1	1	2	1	1	1		1		9
	20											1	1	2	1	1	1	1		8
	21														1	2	1	1		5
	22															1	1	1		3
Total		1	5	9	13	10	11	16	21	17	13	14	12	10	6	7	4	4	1	174



Text-fig. 14. Curve based on the frequencies of flowering periods in Table LXXVII.



Text-fig. 15. Curve based on the frequencies of fruit ripening periods in Table LXXVII.

As we see in the frequency table and the curves, the parents types as regards to the flowering as well as the maturing time do not come forth segregating distinctly, but that the frequencies and consequently the curves are irregular, may imply that different types are involved. The correlation coefficient shows what is the correlation between the flowering time and fruit maturing.

CONCLUSION AND DISCUSSION.

We may draw the conclusion from the above mentioned results as follows:

1. Earliness and lateness make an allelomorphic pair or pairs and behave after the simple Mendelian rule.

2. The character of F_1-plants is intermediate between those of the parents but the character tends to come nearer the later flowering parent.

3. In F_2, segregation of the characters seems to be carried on, but as the flowering periods of both parents are not far apart the two parental types do not come forth distinctly.

4. The genes expressing the characters may be two or three in pairs, but unfortunately as the number of individuals is small the decisive conclusion can not be drawn as to the genes concerned.

There are several investigators of the flowering or fruit maturing time or assosiated with some other characters of plants; such as HOSHINO (1917), KEEBLE and PELLEW (1910), LOCK (1905), MIYAZAWA (1916), NOMURA and YAMAZAKI (1925), RELANDER (1914), TSCHERMAK (1910) and WHITE (1917) are known, but still some others as IKENO (1916) and YAMAGUCHI (1927) more or less touched the same problem.

The experimental results of the above mentioned investigators are not necessarily the same but most of them come to the conclu-

sion that the F_1-generation is intermediate and the factors concerned are two or possibly three.

The characters are very easily affected by the environmental conditions, such as sunlight, temperature, rain fall, etc. Still more if the flowering periods of two parents are very close together, the F_1-plant blooms at or near the same time as the parents, and in such a case the segregation in F_2 will not be perceived or at least the distinction between the different types is very hard, unless some other characters as flower colors be completely associated with the flowering time. But we have not yet such suitable character or characters associated with the periods. But even in such cases we could accomplish the analysis by long perseverance and prudent trials.

XIX. Length of Stem.

As the stem of the Early ripening variety is shorter than that of the I-type, I took the opportunity to investigate this character, though the subject is not new. The characters of the parental stocks and the results of the experiments will be explained by the Tables LXXVIII and LXXIX.

TABLE LXXVIII.

Frequencies.

Parents and hybrids	Year	Gen.	Class centers in CM. for length of stalks												Total
			70	80	90	100	110	120	130	140	150	160	170	180	
Early ripen. variety	1930	P	4	12	17	28	17	15	6	1					100
I-type	1930	P				1	3	7	17	28	26	15	2	1	100
Early ripen. × I-type	1930	F_1		3	5	7	12	17	24	16	11	4	1		100
Early ripen. × I-type	1931	F_2	1	1	6	11	16	21	23	12	6	2	1		100

TABLE LXXIX.

Statistical constants.

Parents and hybrids	Gen.	Mean length	Standard deviation	Coeff. var. in %
Early ripen. variety	P	101.60 ± 1.57	$\pm 15.66 \pm 1.11$	15.41 ± 1.13
I-type	P	142.20 ± 1.43	$\pm 14.25 \pm 1.01$	10.02 ± 0.72
Early ripen. × I-type	F_1	126.50 ± 1.94	$\pm 19.42 \pm 1.37$	15.35 ± 1.38
Early ripen. × I-type	F_2	121.30 ± 1.77	$\pm 17.74 \pm 1.25$	14.62 ± 1.27

The Table LXXVIII represents the frequencies which are reduced to 100 in totals from nearly 200 individuals as they may be plotted to curves. The Table LXXIX represents the statistical constants based on the frequencies represented in Table LXXVIII, and though in the table the cropped years are not described they are the same as in the frequency table.

F_1-GENERATION. As is shown in Table LXXIX the stem length of this generation is nearly intermediate between those of the parental stocks as the means show it.

F_2-GENERATION. As is given in Table LXXIX the mean length of this generation is also intermediate and it exhibits about the same mean as F_1, but the standard deviation and the coefficient of variability are rather smaller than those of F_1, although the limits of frequencies seem to extend pretty large according to Table LXXVIII. If we plot a curve based on these frequencies of F_2, it does not seem to show any sign of bi- or polymodal form. These facts suggest that the F_2-population consists of not many but a few factors each of which has an equal effect upon the length of the stalks.

This case somewhat resembles that of *Nicotiana* studied by EAST (1916) and that of maize studied by EMERSON and EAST (1913).

I could not have much time to investigate the behaviors of the later generations, but this may suggest something of the multiple-factor hypothesis.

CONCLUSION AND DISCUSSION.

From the above mentioned experimental results we can draw the conclusion as follows:

1. The data are expressed on a quantitative scale.
2. The stem length of F_1-generation is intermediate between those of the parental stocks.
3. In F_2-generation the length of the parental stocks was not distinguished from each other as far as the frequencies obtained in my experiment are concerned.
4. The factorial analysis is not yet completed, but the features seem to be one of the cases known as the multiple factor.

One and the same character could be treated either in qualitative or in quantitative feature. The case of tall and dwarf peas

experimented by MENDEL, for instance, was treated as a qualitative character and in this case the gap is so large that the shortest tall plants were distinctly taller than the tallest dwarfs, so that precisely within certain limits we could treat them quantitatively, instead of qualitative. My experiment of hair length already stated in the present paper is an example. So the qualitative or quantitative feature is, in my opinion, one of the arbitral methods of experimenters but quantitative treatments are rather hoped in an exact science.

The case in question is not to be explained thoroughly by multiple-factor hypothesis as the number of factors concerned is not large, but it may be justified in the feature of segregation when we think that each factor has a small effect upon the cumulative character.

XX. Miscellaneous Subjects.

There are several miscellaneous subjects to be treated in this connection, but they are mainly collateral products or they might be the natural outcome when the main subjects are treated, and the subjects are: A, relation between the genes; B, synanthy; C, creation of new forms; D, heterosis and E, longevity of seeds.

A. RELATION BETWEEN THE GENES.

Among the phenomena resulted from the interaction of genes, there are such ones termed linkage, multiple allelomorphism etc., and in my experiments some of them have been observed. They will be mentioned and discussed here to some extent.

a. PECULIAR HABITS OF CRYSTALS.

The seed length of I-type is on an average 33.35 in scales and that of II-type is 38.59 as is shown in Tables XXXII-A, XXXIV-A. The seeds of I-type have crystals in the seed-coat. In F_2-generation of the hybrid between these two types we have two sorts of seeds, the one has crystals and the other has none as is already stated.

Measuring the seed length of these two sorts, we find that the average length of any seed having the crystals is nearly the same

as that of I-type whether it is colored or not.

The coating of crystals seems to check the growth of the seeds, so that the most delicious, tender and larger seeds cannot be obtained in this respect.

b. FASCIATION AND OVARY-CELLS.

Fasciated stem is observed to bear very often many-celled ovaries. Probably there exists some linkage between the genes. To see the linkage I crossed back II-type which has the double recessive characters, fasciated stem and many-celled ovary, to one of the F_1-individuals produced by crossing II- to I-type and obtained the following results:

TABLE LXXX.

Year	NT×nt	Nt×nt	nT×nt	nt×nt	Total
1928	29	23	0	20	72
1929	29	14	0	20	63
1931	85	22	0	63	170
Total	143	59	0	103	305

In the table the notation N stands for normal stem which is dominant over fasciated one represented by n, and T stands for two-celled ovary which is dominant over many-celled one represented by t.

Then I-type is represented by the composition of NNTT, II-type by nntt, and F_1 by the composition of NnTt. The gametes of F_1 are NT, Nt, nT and nt; and as the pollen parent is II-type, the genotypes of the results are shown in the first line of Table LXXX.

If free combination had been carried on, the four forms should be in 1:1:1:1 ratio, but the results are not as was expected and this reveals that there might be some linkage among the genes.

As can be seen in Table LXXX there is no fasciated form having 2-celled ovary, therfore we may say that the gene for fasciation does not come in with the gene for 2-celled ovary, i.e., the genes repulse *from each other completely, or in other words, there is no* crossing over between them. Provided that there is not any crossing over and that the gametes are formd in an usual way, there must not be formed any gamete having normal stem and many-celled

ovary, but on the contrary we have 59 individuals there, as can b seen in the third column of the table.

The phenomenon is peculiar, moreover, that the totals of th 2nd and the 5th column are not equal in number. What makes th disagreements with the expectation? We can certainly attribut this to the incorrectness of assortment by the phenotype. Let u explain it.

As was often said already, the stem form is to be affected ver easily by the environmental conditions, especially so when the soi is not rich enough and the plants grow in crowds, the fasciatio does not make its appearance, while the ovary-cells are not to b affected so easily as the stems.

We can therefore suppose that: (1) 59 normal stemmed an many-celled individuals are mistaken which are to be put togethe with 103 in the 5th column as some fasciateds being supposed to b mistaken for normals; (2) in the same reason some of 143 norma stemmed and 2-celled individuals in the 2nd column might be mistake which are to be put in the 4th column; (3) some of the individual in the 2nd and 3rd column are mistaken and they must com under the 4th and 5th column respectively.

Among these three suppositions the 3rd is very likely to happen If we take 20 individuals from the 2nd column and put them in th 4th column, and take 30 individuals from the 3rd column and pu them in the 5th column, we shall have four classes as follows:

NT × nt	Nt × nt	nT × nt	nt × nt
123	29	20	133

This is based on the supposition but the feature will not b far from the expectation, and when calculated on this basis w obtain the crossover value as follows:

Non-crossovers or parental combinations		Crossovers or recombinations	
Normal 2-celled	Fasciated many-celled	Normal many-celled	Fasciated 2-celled
83.93 percent		16.07 percent	

Anyhow it is supposed that the gene for fasciation has grea tendency to link with that for many-celled ovary, hence the tw genes are located in the same chromosome.

B. Synanthy.

Synanthy in the meaning of Worsdell's term is often observed in certain plants, when the flowers are crowded in one part of an inflorescence. The phenomenon occurs in the fasciated plants of *Sesamum*, especially so when the degree of fasciation is great, but the phenomenon has never been observed in normal stemmed plants, that is I- and III-type. Many-celled ovary must be strictly distinguished from the many-celled one and this can sometimes be by the presence of the coalesced leaves from the axil of which the synanthial fruits are produced as is shown in Pl. V, Figs. 27, 28, 29 and 30.

C. Creation of new Forms.

We obtained several new forms by the combination of genes as most of them segregate and recombine freely, but such is not the object of my experiments.

D. Heterosis.

Heterosis results in vigor in most cases but in my experiments it was not so conspicuous and, on the contrary, inbreeding for so many years as over 20 years did not seem to degenerate the vegetative organs. This is probably due to the fact that the likeness of nature or chromosomes in my materials is not apart so far.

E. Longevity of Seeds.

Longevity of seeds generally has its wide range according partly to the hereditary nature of the plant and partly to the environmental conditions in keeping the seeds. Many investigators, therefore, have hitherto done various experiments either from economical or from physiological side, and the reports relating to the subjects are accumulating on this line.

Ewart's enumeration is noted in this line but his enumeration has hardly much weight from the scientific standpoint (Ewart, 1908). Wichura's classic work on the hybridization of willows is also noted, and the work called attention to the longevity of willow seeds whose

longevity is so small that it ends within about a week (WICHURA, 1865).

I experimented on the longevity of some *Salix* seeds some years ago and I found that the longevity of the seeds is also very small and I tried to prolong the duration of their life by suitable preservation but I could not keep them alive more than 15 days at that time (NOHARA, 1910). Afterwards NAKAJIMA (1921) devoted his time during 5 years to the investigation of longevity and he was able to preserve the seeds of some *Salix* in germinable condition in about 50% for a year. These important experiments relate to the physiological interest but I doubt that the materials have not been genetically pure, and if not so, I regret that the validity of the results of the experiments might be lessened to some measure, because dioecious plants as willow trees are very naturally to be crossed when there were some other kinds near there. This is a matter of worth to consider from genetical standpoint.

Under the consideration of genetics, I experimented on the germination power of some willow seeds (NOHARA, 1931) and contributed some knowledge on this line and now I shall try to add some more by the experiments of sesame seed. The materials used to this purpose were taken from the seeds continually selfed, but really fertilized through xenogamy, for more than 10 years in the same lines of I-type and their crossed seeds which, if sown, would give F_1-plants having the same genetical constitution. The experiments were undertaken in two series.

a. FIRST SERIES.

The experiments of this series were performed twice from September until October 20th 1926, and in the first experiment 100 seeds and in the second 50 seeds in each lot were used, but in the latter case the seeds of F_1-lot were less than 50 in number for I did not have enough quantity to fill up. The ages of ordinary air dried seeds range from 1921 to 1925, and they were set in the following arrangement in a LIEBENBERG'S germination apparatus each time.

A-EXPERIMENT. In this experiment the seeds were sown without any preliminary treatment on a blotting paper each lot, laid on a bridge as is shown in the following table:

TABLE LXXXI.

	I-type, P		II-type, P
	1921, (100)		1921, (100)
	1922, (100)		1922, (100)
	1923, (100)		1923, (100)
	1924, (100)		1924, (100)
	1925, (100)		1925, (100)
	F_1		
	1921, (100)	1922, (100)	1923, (100)
	1924, (100)		1925, (100)

(Experimented in 1926)

This table shows the location of seeds sown on the bridge in the apparatus and the numbers in brackets represent those of the seeds actually used.

After 5 days some of them germinated and their hypocotyls have grown to attain a hight of about 3 centimetres almost simultaneously. In examining the germinated seeds we obtained the following:

TABLE LXXXII.

	I-type, P			II-type, P			F_1		
Year	Strong	Weak	Total	Strong	Weak	Total	Strong	Weak	Total
1921	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0
1924	63	8	71	66	10	76	70	2	72
1925	92	4	96	95	3	98	94	3	97

As the number of germinated seeds are represented directly in percentages of germination, we are able to perceive from the table at once how many have failed to germinate, and how high the germination energy is by the numbers under the heading of "strong" too.

B-EXPERIMENT. In this experiment the treatment is a little different from the preceding one, i. e., this time 50 seeds in each lot from I-type and II-type, and 25 seeds from some of the F_1-type

produced in the crossing between the I-type and the II-type were used and they were arranged as is shown in the following table.

TABLE LXXXIII.

I-type, P		II-type, P
1921, (50)		1921, (50)
1922, (50)		1922, (50)
1923, (50)		1923, (50)
1924, (50)		1924, (50)
1925, (50)		1925, (50)
	F_1	
1921, (50)	1922, (50)	1923, (50)
1924, (50)		1925, (25)

Previously to sowing, the seeds were caused to absorb a sufficient quantity of water by means of vacuum pump and then they were prepared as before but this time the F_1-seeds were sown two days later than those from the parent stocks.

In this way we noticed some seeds to germinate after 12 hours from the time of sowing. Certain days later some of the seedlings in the F_1-lot have grown and attained the height from 3.6 cm. to 1.0 cm. and the results of the examination obtained are as follows:

TABLE LXXXIV.

Germination test performed in 1926.

	I-type, P			II-type, P			F_1		
Year	Strong	Weak	Total	Strong	Weak	Total	Strong	Weak	Total
1921	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0
1924	68%	11%	79%	64%	7%	71%	63%	5%	68%
1925	90%	5%	95%	92%	5%	97%	88%	6%	94%

The germination capacity is represented in percentages and the energy of germination can also be seen in this table.

b. SECOND SERIES.

I prepared the seeds on July 6th 1928 at noon on the LIEBEN-ERG's apparatus according to the following arrangement and the umbers in brackets in the table indicate those of the seeds prepared.

TABLE LXXXV.

Cropped on	I-type, P	F_1	II-type, P
1923	(80)	I×II-(80)	(80)
1924	(40)	I×II-(40), II×I-(40)	(80)
1925	(4)	I×II-(5)	(28)
1926	(80)	I×II-(10), II×I-(10)	(80)
1927	(80)	I×II-(80)	(80)

After two days, germinated seeds were noticed as follows:
)27-year: I-type, 80 seeds; I×II-F_1, 78 seeds; II-type 79 seeds.

Still two days later, germinated seeds besides the above men-oned were counted as following:
)26-year: I-type 46 seeds; I×II-F_1, 1 seed; II-type, 13 seeds.

The next day, July 11th, we counted the germinated seeds and)tained the following which is the total number noticed at the 5th ıy after the preparation:

TABLE LXXXVI.

Year	I-type	F_1	II-type
1926	46 seeds	I×II, 1 seed. II×I, 2 seeds	22 seeds
1927	80 seeds	I×II, 78 seeds	79 seeds

When we take together the germinated numbers of the reciprocal ⁄brids on 1926 and calculate the percentage of seeds hitherto ərminated, we obtain the following table:

TABLE LXXXVII.

	I-type			II-type			F_1		
Year	Strong	Weak	Total	Strong	Weak	Total	Strong	Weak	Total
1923	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0
1926	51%	7%	58%	25%	3%	28%	14%	1%	15%
1927	95%	5%	100%	93%	6%	99%	92%	6%	98%

As is stated above, the experiments were stopped at noon on July 11th, and then I measured the length of hypocotyls and radicles of 40 seedlings from the two types and the hybrid cropped in 1927 and the average length so far obtained is as follows:

TABLE LXXXVIII.

	I-type	$I \times II\text{-}F_1$	II-type	Average
Hypocotyl	2.36 cm.	2.68 cm.	2.46 cm.	2.50 cm.
Radicle	3.83 cm.	3.60 cm.	2.75 cm.	3.39 cm.

From these results we see that the length of hypocotyl is a little shorter than that of radicle on an average but they show some differences in length among themselves, according to the conditions of environment and the ages of seedlings.

For 4 days I left the seeds stand in this way and two seeds of $II \times I\text{-}F_1$ lot cropped in 1924 have pushed out a bit of part of embryo but being crooked abnormally did not elongate any more.

The next day I took out the seedlings of 3 lots cropped in 1927 from the germinating apparatus and transplanted on the ground and cultivated as usual. They came to bloom on the beginning of October, though some of them were destroyed by insects or some other causes.

The growth and blooming of these plants were closely watched after transplanting and it was noticed that the hybrid lot was rather poor in these respects.

CONCLUSION AND DISCUSSION.

From the experiments of above mentioned two series we can draw the following conclusion:

1. The percentage of germination is lessened as the seeds are kept longer and though the exact limitation of the longevity is not known yet, we can easily think that the germination capacity of *Sesamum* seeds preserved in an ordinary way can hardly maintain more than two years.

2. The germination capacity of the seeds of I- and II-type is *not only larger than that of their hybrid* but also the germination strength of those types is larger than that of their hybrid.

. Originally the longevity of seeds is not of the same in general according to the varieties of plants which produce the seeds. Although we know the fact that the longevity of seeds can be prolonged by a suitable preservation performed artificially or accidentally in nature as was done by NAKAJIMA (1921) and many others or as in the case of lotus fruit investigated by OHGA (1927), yet the longevity is naturally limited.

To the physiological nature relating to the devices of preservation in germinable condition, many experimenters have given their plausible explanations but I am not in the place to touch upon these problems now. I was to see the longevity of *Sesamum* seeds in an ordinary air dried condition but at the same time I was able to find out the fact in this plant that the seeds of a hybrid-plant do not maintain more germination power and strength than those of the parental stocks. This fact suggests that the heterozygous plant is indifferent from the homozygous plants in this respect.

XXI. Summary.

1. The present studies are on the characters of the three varieties of *Sesamum indicum*, L., the White sesame, the Black sesame and the Brown sesame, designating them as I-type, II-type and III-type respectively.

2. Fasciation occurs in the stem of II-type only and in the hybrids with the normal stem of I- and III-type the normal was proved to be dominant over the fasciated. The allelomorphic character is displayed by two-gene difference in non-cumulative way, so that in F_2-generation the normal and the fasciated plants come out in the ratio of 15: 1 respectively. The heterozygotes segregate in later generations after the simple Mendelian rule.

3. Unbranching habit of the stem is dominant over branching one and the character is displayed by one-gene difference. The heterozygotes segregate after the simple Mendelian rule in later generations.

4. Compoundness of leaves is dominant over the simpleness of the same and the character is displayed by one-gene difference. The heterozygotes segregate after the simple Mendelian rule, but the character is to be affected very easily by the environmental conditions, so that the actual number of the results often does not agree with

the expectancy.

5. Variegation is sometimes observed very conspicuously but it has been proved by genetical tests to be always ephemeral.

6. The character of long hairs in the plant body is imperfect dominant over that of short hairs and the character is displayed by one-gene difference. The heterozygotes segregate in later generations after the Mendelian rule.

7. The appearance of the nectar glands in the leaf-axil is dominant over its allelomorph, the appearance of the accessory flowers, and the allelomorphic character is displayed by one-gene difference. The heterozygotes segregate after the simple Mendelian rule in later generations.

8. Opening fashion of the corolla lips is perfect dominant over the closed fashion and the character is displayed by one-gene difference. The heterozygotes segregate in later generations after the simple Mendelian rule.

9. In the color of corollas the deeper color is imperfectly dominant over the lighter color and the character is displayed by one-gene difference. Heterozygotes segregate after the simple Mendelian rule in later generations.

10. In the ovary-cells 2-celled is perfectly dominant over the many-celled and the character is displayed by one-gene difference. The heterozygotes segregate after the simple Mendelian rule in later generations.

11. Between the length and breadth of seeds there is a very slight correlation or no correlation at all, so that one character cannot be taken as an index of the other, because the breadth is to vary according to the number of ovary-cells while the length is almost always stable in spite of the number of cells. In the experimental results of the length it was found that the length of the hybrids is almost intermediate and the character is displayed by one-gene difference. The heterozygotes segregate after the simple Mendelian rule.

12. In the color of the seed-coat the Black of II-type is perfectly dominant over the White of I-type and the allelomorphic characters are displayed by two-gene differance. The genes of F_1-individuals segregate without any linkage and recombine freely, so that there appear four kinds of seeds in the ratio of 9:3:3:1 in the next generation.

In the hybrids between II- and III-type, the Black of II-type was proved to be perfectly dominant over the Cinnamon Buff of III-type, and in F_2 we obtain four kinds of seeds in 9 : 3 : 3 : 1 ratio, so that it is obvious that the characters are displayed by two-gene difference.

In the hybrids between III- and I-type, the Cinnamon Buff of III-type was proved to be perfectly dominant over the White of I-type, and in F_2 we obtain four kinds of seeds in 9 : 3 : 3 : 1 ratio, so that it is obvious that the characters are displayed by two-gene difference, and that between the genes no linkage exists.

After all the Black of II-type is the highest, the White of I-type is the lowest and the Cinnamon Buff of III-type is intermediate in respect of dominancy.

13. The presence of deposition of the crystals of calcium oxalate in the epidermal cells of the seed-coat of I-type is recessive to the absence of the same in II- and III-type, and the heterozygotes segregate in the ratio of 3 : 1 after the simple Mendelian rule. It is obvious that the character is displayed by one-gene difference.

As the presence of the thickening of the side-wall is in antagonism with that of the crystals, it might be said that the thickening of the side-wall is, in turn, dominant over the presence of the crystals: and as the thickening is always accompanied by the presence of the diaphragm in the bottom wall, the presence of the diaphragm also might be said to be dominant over the presence of the crystals. Then the hereditary behavior of the diaphragm against the crystals could be known with that of the thickening.

14. The smoothness of the seed-cost is almost perfectly dominant over the roughness of the same and the character is displayed by one-gene difference. The heterozygotes segregate after the simple Mendelian rule in later generations.

15. Quality of oil in the seeds of I- and II-type is not different, but the quantity is not of the same, and the hereditary nature of the latter type is investigated, but as we have no means of calculating the weight of the embryo in each seed, we can not say any more about the hereditary nature than to infer that it will behave after the simple Mendelian rule from the results of experiments of other characters of the seeds.

16. In the characters of earliness and lateness the heterozygotes have proved to be intermediate but tending to come nearer the

later flowering parent. The character seems to be displayed by two or three-gene difference and in my experiments on the character the material was not sufficient for deciding the number of the allelomorphic genes and the hereditary behavior.

17. In the length of stems the F_1-individuals have shown that the character is intermediate between those of the parents and the character seems to be explained by multiple factor hypothesis though it has not been thoroughly investigated.

18. There are numeral cases in which allelomorphic genes hold the linkage or correlation to some extent but here I have one of peculiar cases which exists between the genes of the crystals of calcium oxalate and those of the length of seeds. If the crystals are present the seeds are comparatively short and consequently roundish. From the above mentioned facts it is known that the most delicious and tender seeds like those of I-type having the length like those of II-type is impossible to obtain.

19. Between the gene or genes of fasciation and those of many-celled ovary some linkage may exist.

20. Synanthy of the fruits occur in the plant of II-type but in any other types such phenomenon could not be observed. This phenomenon should be distinguished from many-celled fruits or ovaries.

21. No word is needed about the creation of new forms produced by the combination of genes excepting such cases mentioned in 18th section of this summary.

22. Heterosis does not cause any vigor in my materials probably due to the slight difference of the chromosomes though the genes are much different.

23. The longevity of seeds can hardly be maintained more than two years in an ordinary preservation.

In conclusion I wish to express my sincere thanks to Professor IKENO who gave me helpful suggestions and allowed me to use his literature, and also to Professor MIYAKE and Professor KOMINAMI who have encouraged me to accomplish the present work and have been generous to read my manuscript. Thanks are also due to Mr. HATAKOSI of the Agricultural experiment Station of Ibarakiken for the favor of the material, Early ripening variety. It will be my duty to extend my thanks to four gentlemen, Dr. Iino, Mr. ANDÔ, Mr. SAITÔ and Mr. TOPPATA who helped me in my work.

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EXPLANATION OF PLATES.

PLATE I.

Plants of three types showing general features, much reduced.

Fig. 1. Part of I-type.

Fig. 2. Part of II-type with fasciated stem.

Fig. 3. Part of III-type.

PLATE II.

Plants of three types showing hairs, flowers and position of extranuptial nectaries.

Fig. 4. I-type.

Fig. 5. II-type with normal stem.

Fig. 6. III-type.

PLATE III.

Plants of three types showing branching habit, fasciation of stems and position of fruits.

Fig. 7. I-type.

Fig. 8. II-type, three plants to the left having normal stems and three others to the right having fasciated stems.

Fig. 9. III-type.

PLATE IV.

Leaves of three types.

Fig. 10. I-type showing its compound as well as simple leaves.

Fig. 11. II-type showing only its simple leaves.

Fig. 12. III-type showing its compound as well as simple leaves.

PLATE V.

Normal and abnormal leaves with their fruits showing ovary-cells and synanthy.

Fig. 13. I-type.

Figs. 14, 15, 16, 17. II-type.

Figs. 18, 19, 20, 21, 22. Synanthies of fruits and leaves of II-type.
Fig. 23. Cross-section of a fruit of I-type.
Figs. 24, 25, 26. Cross-sections of fruits of II-type.
Figs. 27, 28, 29, 30. Synanthies of fruits of II-type.

PLATE VI.

Photomicrographs showing the hairs of three types and those of the hybrids.
Fig. 31. I-type.
Fig. 32. II-type.
Fig. 33. III-type.
Fig. 34. Hybrid between I- and II-type.
Fig. 35. Hybrid between I- and III-type.
Fig. 36. Hybrid between II- and III-type.

PLATE VII.

Photomicrographs of sections of seed-coat, showing the structure.
Figs. 37-A, 37-B, 37-C. I-type.
Figs. 38-A, 38-B, 38-C. II-type.

PLATE VIII.

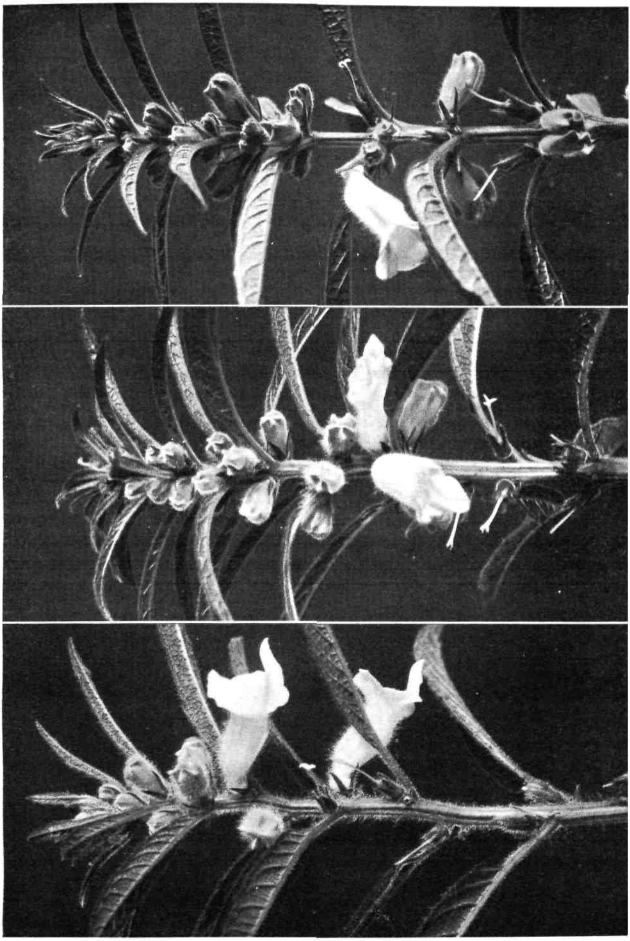
Photomicrographs of sections of seed-coat; and seeds showing the surface of the testa of three types.
Figs. 39-A, 39-B, 39-C. III-type.
Fig. 40. Seeds of I-type.
Fig. 41. Seeds of II-type.
Fig. 42. Seeds of III-type.

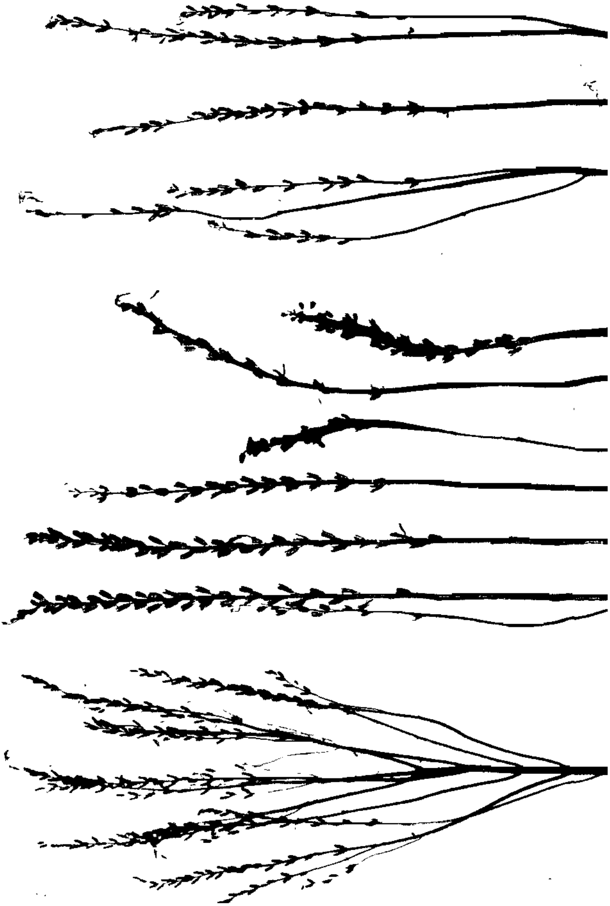
PLATE IX.

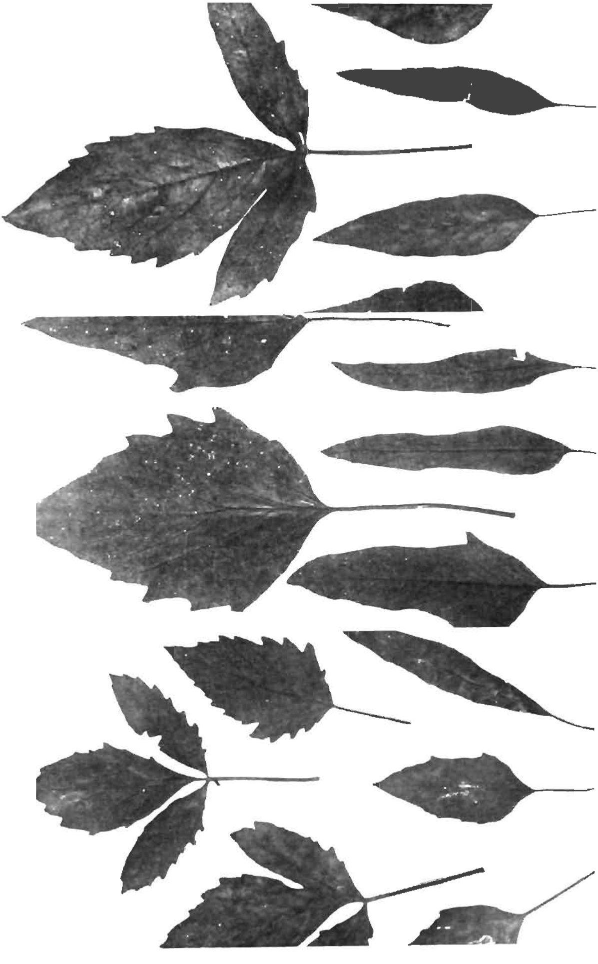
Plants of the hybrids showing branching habit, stem nature and fruit position.
Fig. 43. Hybrid plants between I-type and fasciated II-type.
Fig. 44. Hybrid plants between I- and III-type.
Fig. 45. Hydrid plants between fasciated II-type and III-type

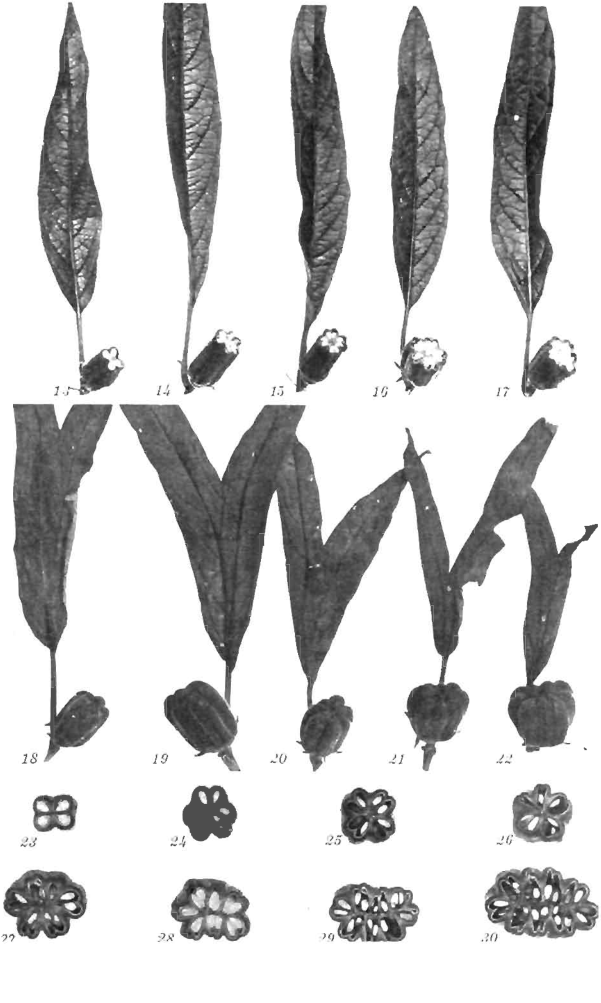
PLATE X.

Cell structure of the seed-coat of three types.
Figs. 46-A, 46-B, 46-C. I-type.
Figs. 47-A, 47-B, 47-C. II-type.
Figs. 48-A, 48-B, 48-C. III-type.
o, i. outer and inner layer of seed-coat (S); E, endosperm.





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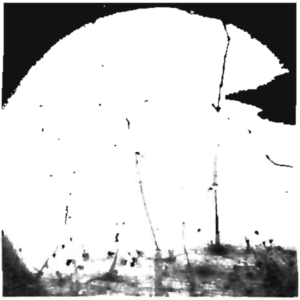

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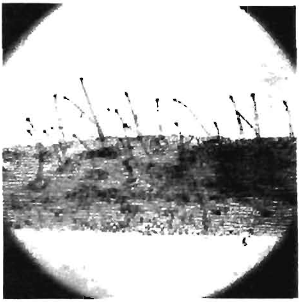

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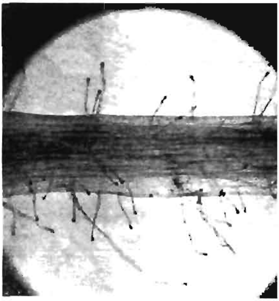

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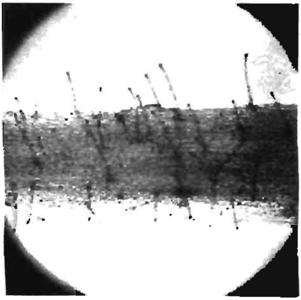
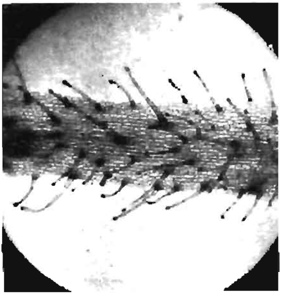
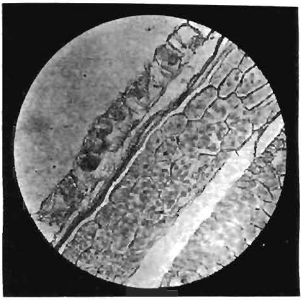
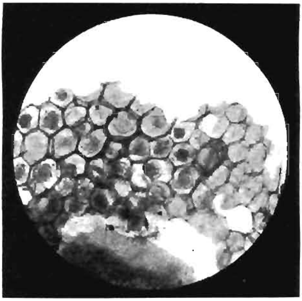






37–A

38–A



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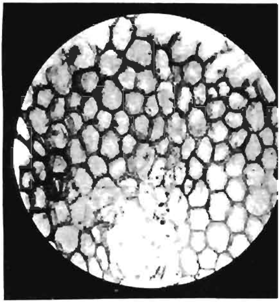

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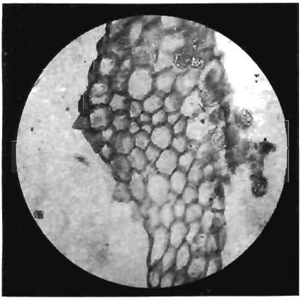

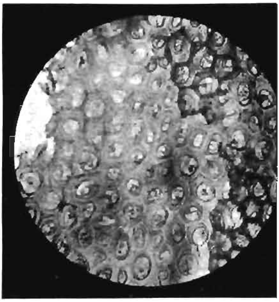

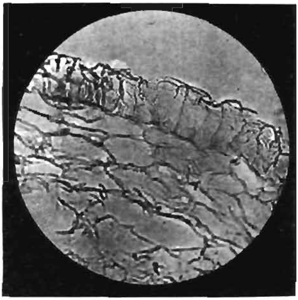

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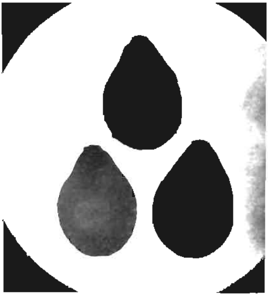

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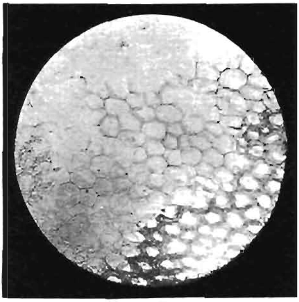

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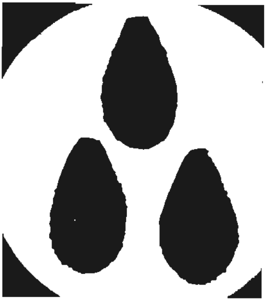

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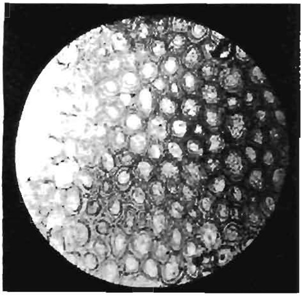

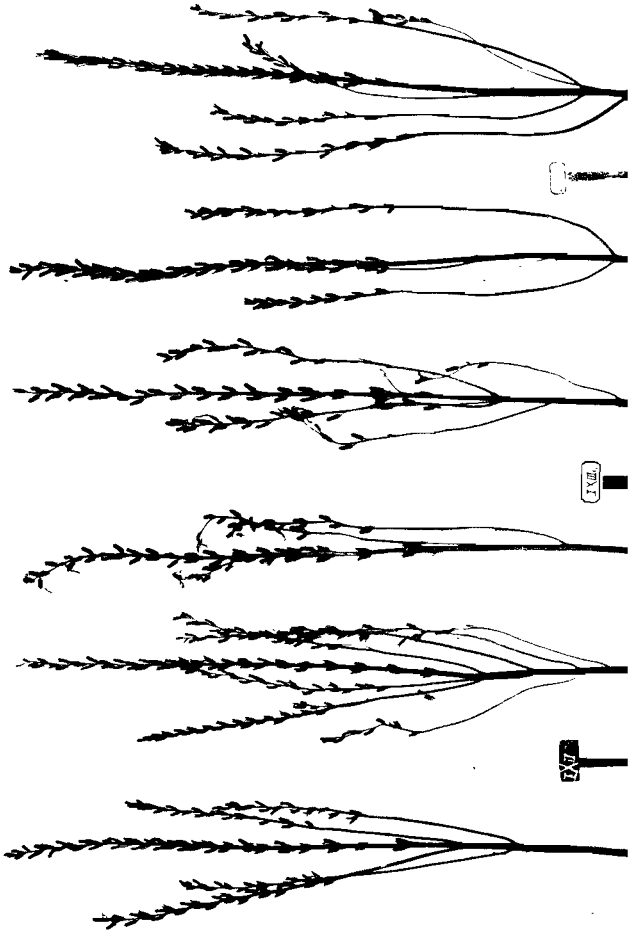

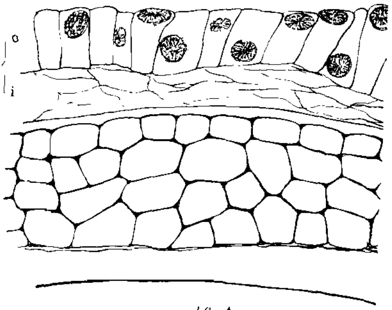

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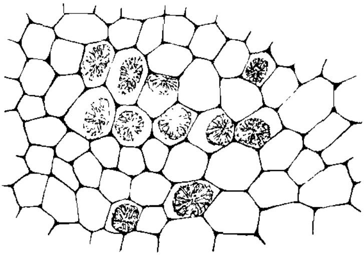

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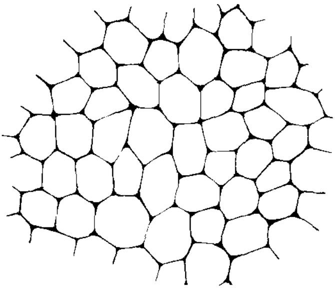
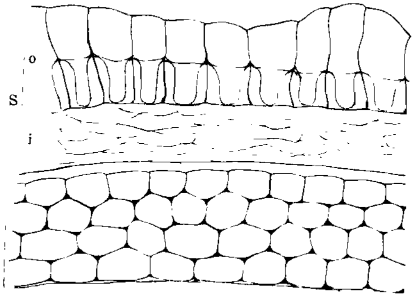


Plate X.



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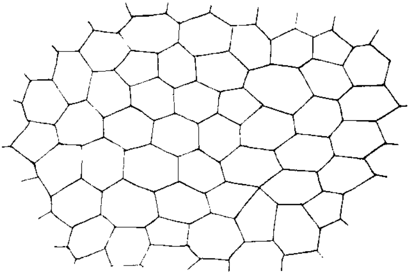

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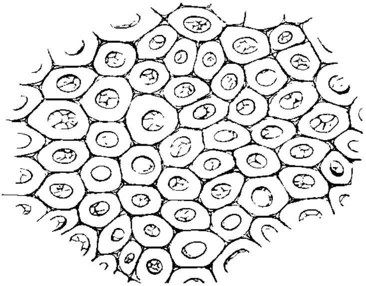

The Mode of Duplication of Petals in the Double Flowers of Prunus Mume.

By

Yoshitaka Imai.

With Plate XI and five Text-figures.

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Introduction.

Many garden varieties of *Prunus Mume*, SIEB. et ZUCC., including flowers of various degrees of doubleness, have long been cultivated in Japan. NOHARA (1913) is the only writer who has made statistical investigations on the doubling of this plant, with particular reference to the manner in which the petals increase. With the cooperation of Mr. B. KANNA, I, myself, have also been studying the same subject on a relatively large scale for the last fifteen years or so. Owing however to presure of other work, the investigations progressed very slowly. In the present paper, I have made clear how the duplication of petals in the double flowers is accomplished. The process of duplication, which is quite mechanical, is in accordance with a definite system. Counts were made from flowers

of twenty-five varieties or stocks grown in the Botanical Garden of the Agricultural College, Tokyo Imperial University. Since, with the exception of a few, the names of the varieties are not known with certainty, I shall designate them by the stock numbers. There can scarcely be any objection to this, seeing that the present study is not an attempt to determine the characteristics of the doubling in each variety, but to describe its general mechanism. The names are known of the following stocks: Sabashibeni (stock 9), Hakubotan (stock 11), Tamashibori (stock 14), and Naniwa (stock 23).

Variation in the Number of Sepals.

Although *Prunus Mume* has 5 sepals, they show at times some variation, which, because of the fact that the number of sepals determines the number of basic petals, cannot be ignored in this investigation. Thus, when there are 6 sepals there are also 6 petals, the two numbers agreeing. The variation in the number of sepals in the stocks examined are shown in Table I.

TABLE I.

Variation in the number of sepals in various stocks.

Stock No.	Total	4	5	6	7	8	Modal coefficient (%)
1	100		**100**				100.00
2	100		**100**				100.00
3	100		**100**				100.00
4	100		**100**				100.00
5	100		**96**	4			96.00
6	100		**100**				100.00
7	373		**363**	10			97.32
8	320		**202**	114	4		63.13
9	400	1	**379**	19	1		94.75
10	200		**196**	4			98.00
11	200		**198**	2			99.00
12	200		**193**	7			96.50
13	777		**635**	131	11		81.72
14	330		**275**	50	5		83.33
15	100		**97**	3			97.00
16	400		**329**	69	2		82.25
17	512	1	**497**	14			80.02
18	220		**220**				100.00
19	150		**150**				100.00
20	161		**144**	17			89.44
21	50		**44**	4	1	1	88.00
22	114		**112**	2			98.25
23	330		**330**				100.00
24	200		**200**				100.00
25	30		**29**	1			96.67

While some of the stocks show none or almost no variation in the number of sepals, others exhibit fluctuations to 6, 7, or even (in one case only) to 8. Very rarely flowers have only 4 sepals. The modal coefficient is lessened in an extreme case (stock 8) to 63.13 percent, more than about one-third of the flowers having extra sepals. These sepals are sometimes undersized and imperfectly developed. In every case the mode is 5, therefore, neglecting the rare occurrence of flowers with 4 sepals, the variation, if it occurs, always represents a half-curve. When single flowers have 4 sepals, the petals present crossing corollas.

Variation in the Number of Petals.

Since the basic petals that are situated inside the intra-sepals determine the number of petals, flowers with abnormal calyx have been disregarded in Table II, which gives the variation in the number of petals, only flowers with 5 sepals being considered.

Except one, all the stocks exhibit more or less variation in the number of petals, the fluctuation in the majority of cases being conspicuous. The mode also differs considerably in the various stocks, ranging from 5 to over 30. Since in stocks 1—8 the mode is 5, their flowers are singles (Pl. XI, fig. 1) or mostly singles. Of these, stocks 1—5 may practically be regarded as singles, but not stocks 6—8, where flowers with additional petals frequently occur or are predominant. NOHARA'S stock, Kôrai, corresponds to my stock 6 in its degree of doubling. Stocks 9 and 10 (Pl. XI, fig. 3) have their respective modes at 7 and 9, fluctuating on the two sides of the mode from 5 to 14. These types of doubling associate stocks 7 and 8 with another type stock 11 (Pl. XI, fig. 2), in which fluctuation occurs on both sides of mode 15. The fluctuation in stock 11 nearly corresponds to NOHARA'S stock, Matusima, though they are quite unlike in other characters. Stock 12 (Pl. XI, fig. 4) shows variation in a half-curve with the mode at 5. A variation similar to the latter is observed in stocks 13—16. Why such a half-curve should occur will be explained in a later section. Stock 16 shows a wide range of variation, transmitting the degree of doubling to the next step. In stocks 17—24 (Pl. XI, fig. 5), the doubling is more extended, presenting gradually increasing modal values. The extreme type is found in stock 25, in which the mode seems to be

TABLE II.

Variation in the number of petals in various stocks.

Stock No.	Total	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
1	100	**100**																																																
2	100	**99**	1																																															
3	100	**99**	1																																															
4	100	**93**	5	2																																														
5	96	**88**	7			1																																												
6	100	**88**	6	5	1																																													
7	363	**194**	78	60	17	11	3																																											
8	202	**65**	36	51	33	14	3																																											
9	379	35	53	**108**	68	65	23	20	6		1																																							
10	196	1	11	26	**27**	**36**	32	33	15	6	9																																							
11	198								1	4	30	**107**	40	9	3	4																																		
12	193											**124**	35	18	11	2	1	2																																
13	635										1	**374**	139	77	33	4	3		3	1																														
14	275											**138**	67	41	20	4	5																																	
15	97										1	**35**	31	18	6	4	2																																	
16	329											**69**	56	43	45	42	30	17	11	8	5	2	1																											
17	497											25	69	99	**108**	98	50	35	8	4		1																												
18	220											2	4	11	15	22	36	**41**	29	26	15	13	4		2																									
19	150												5	5	4	10	11	10	**21**	**21**	14	14	14	7	5	4	5																							
20	144													3	3	4	7	9	16	13	11	17	**20**	14	11	2	6	7	1																					
21	44																	1	1	1	1	3	1	5	**12**	8	10	1																						
22	112																		1		2	13	10	17	19	**21**	9	11	4	3	1	1																		
23	330																			1	3	14	25	30	**54**	**53**	**54**	42	25	15	7	5	2																	
24	200																	1		1	1	1	4	3	12	34	**49**	41	27	14	5	4	1	1	1															
25	29																											1	3		1		1		1	1	3		1	1		3	1	3	1	2	4	1		1

about 40 or more. The variation of petals shown by these stocks ranges from 5 to 53. A mathematical treatment of the fluctuating variation in the various stocks is given in Table III.

TABLE III.

Mathematical treatment of variation in the number of petals.

Stock No.	M	σ	C (%)
1	5.000±0.000	0.000±0.000	0.000±0.000
2	5.010±0.007	0.099±0.005	1.976±0.093
3	5.010±0.007	0.099±0.005	1.976±0.093
4	5.090±0.024	0.349±0.016	6.856±0.323
5	5.115±0.033	0.476±0.023	9.306±0.448
6	5.190±0.038	0.560±0.026	10.790±0.514
7	5.871±0.041	1.148±0.029	19.554±0.508
8	6.525±0.064	1.346±0.045	20.627±0.723
9	7.689±0.058	1.676±0.041	21.797±0.558
10	9.505±0.098	2.040±0.069	21.462±0.763
11	15.212±0.050	1.037±0.035	6.817±0.231
12	15.668±0.055	1.131±0.039	7.219±0.248
13	15.710±0.030	1 106±0.021	7.040±0.134
14	15.909±0.047	1.164±0.033	7.317±0.210
15	16.134±0.085	1.236±0.060	7.661±0.369
16	17.778±0.090	2.406±0.063	13.534±0.362
17	18.101±0.052	1.729±0.037	9.552±0.205
18	21.050±0.110	2.413±0.077	11.463±0.373
19	22.980±0.183	3.334±0.130	14.508±0.577
20	24.604±0.190	3.379±0.134	13.734±0.556
21	27.841±0.226	2.225±0.160	7.992±0.573
22	28.232±0.149	2.345±0.105	8.306±0.374
23	29.261±0.089	2.370±0.062	8 100±0.213
24	30.440±0.103	2.156±0.073	7.083±0.239
25	43.138±0.814	6.516±0.586	15.105±1.388

The mean (M) differs considerably in the different stocks, varying from 5.000 ± 0.000 to 43.138 ± 0.814. The standard deviation (σ) also varies from zero to $\pm 6.516 \pm 0.586$. Roughly speaking, the mean is loosely correlated with standard deviation. This relation is seen more clearly in the coefficient of variability (C). The coefficient of variability is exceptionally high in stocks 7—10, the cause of which is high degrees of petalody.

Mode of Duplication.

As shown in Table II, stocks 12—16 had their modes at 15, the fluctuation showing up toward the increasing side, but scarcely at all toward the decreasing side. Variation in a half-curve is also found in some of the single or semi-double stocks, such as Nos. 2—8. In these last cases, the reason for the variation however is clear. It is that the sepals, of which there are 5, determine the number of basic petals. In the former cases, mode 15 resulted from a set of petalomany or duplication of petals, that occur inside the basic petals. As the duplication occurs in a definite system and in further succesvie stages, we may call this simplest case a primary duplication, which takes place in the manner shown in Fig. 1A. The duplicated petals occur inside the basic petals on both their sides, so

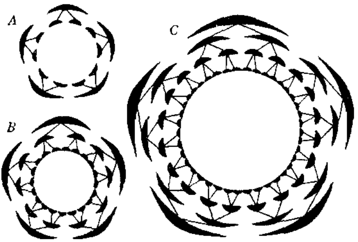

Fig. 1. Floral diagrams of double types forming primary (A), secondary (B), tertiary (C) duplications. The outer crescents indicate basic petals and the inner the duplicated petals of different degrees of doubling.

that the petals of the flower, including the basic (5) and duplication (10), amount to 15 in number, when it is a complete primary duplication. In stock 11, the primary duplication in some flowers is incomplete. On closely examining flowers having many more petals, it was found that secondary duplication takes place in the manner shown in Figs. 1B and 2. Theoretically the scheme for secondary duplication seems to be as that shown in Figs. 1B and 2A, but the

set is disturbed on account of the small space of the receptacles, resulting often in the modified schemes shown in Figs. 2B and 2C. In these schemes, secondary duplication results in total petals of 25, 30, and 35 respectively. Complete secondary duplication therefore produces double flowers with petals numbering from 25 to 35. Some or most of the flowers of stocks 11—24 underwent, partially or incompletely, such duplication, while some or most of the flowers of stocks 16—24 underwent complete secondary duplication. A few flowers of stocks 23—24 and the majority of the flowers of stock 25 have over 35 petals, the numbers varying from 36 to 53. The increase of petals in these flowers seems to be due to a further step in duplication, or tertiary duplication. The mode of tertiary duplication cannot be clearly made out from a mere inspection of the duplicated petals in the flowers, owing to the extra petals that are crowded in the small receptacles. Theoretically, however, it should be as shown in Figs. 1C and 3A. The modified forms of tertiary duplication includes flowers of some unlike forms, ranging to the simplest one as shown in Fig. 3B. The total number of petals in flowers that have undergone complete tertiary

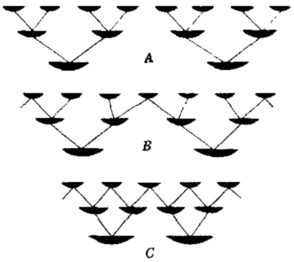

Fig. 2. Typical (A) and modified (B and C) secondary duplications. The lower crescents in the various sets indecate basic petals, the middle the primary duplicated, and the upper the secondary duplicated petals.

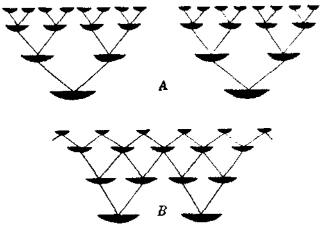

Fig. 3. Typical (A) and simplest (B) tertiary duplications.

duplication may be 35, 40, 45, 50, 55, 60, 65, 70, and 75. Typical secondary duplication overlaps simplest tertiary duplication in the matter of number of petals. Owing to space limitation in the receptacles, in stock 25 the increase in the number of petals seems to have approached the limit. Thus duplication, or petalomany, follows definite schemes in the double flowers of this plant, and not haphazardly. Partial duplication links the different degrees of complete duplications. Owing to the number of petals being not too many, primary duplication occurs rather regularly in the double flowers, frequently showing variations in a half-curve. In these stocks, primary duplication was uncompleted only in a very small number of flowers with 14 petals. In stocks showing secondary or tertiary duplications, owing to space restriction in the receptacles, the variation of petals make normal or nearly normal curves; in other words, many flowers show imperfect duplications. In Fig. 4 are graphed

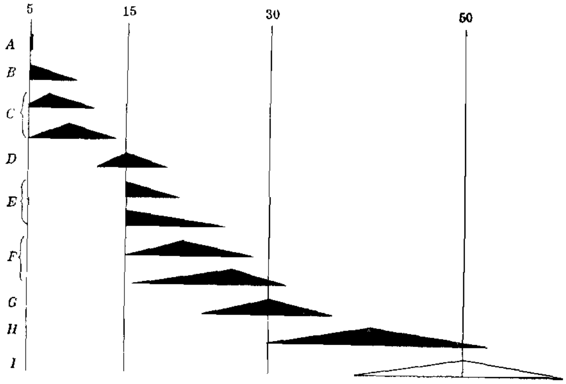

Fig. 4. Diagrammatic representation of variation in the number of petals in various stocks. The white triangle is however theoretical.

diagrammatic representations of variation in single, semidouble, and various duplicated flowers, including a theoretical type of complete tertiary duplication with fluctuations. In the diagram, A (corresponding to stock 1 and also to stocks 2 and 3) represents complete

single, D (corresponding to stock 11) indicates primary duplication with fluctuations, and B and C (corresponding to stocks 4—10) links these standards. In E (corresponding to stocks 12—16) primary duplication is completed and further petalomany takes place. In G (corresponding to stocks 20—24), secondary duplication occurs, and F (corresponding to stocks 17—19) links E to G. With further duplication, case I (tertiary duplication) occurs, passing the intermediate type H (corresponding to stock 25). Type I however is graphed only theoretically.

Variation in the Number of Stamens.

The variation in the number of stamens is very conspicuous, the extent of the variation differing greatly in the different stocks, ranging from 33 to 116. In Table IV are shown the counts of the stamens.

Roughly speaking, with certain exceptions, single and semi-double stocks have a relatively small number of stamens, whereas duplication accompanies increase of stamens. A mathematical treatment of the number of stamens is given in Table V.

TABLE V.

Mathematical treatment of variation in the number of stamens.

Stock No.	M	σ	C (%)
1	50.870±0.135	2.006±0.095	3.943±0.186
2	51.720±0.134	1.980±0.093	3.828±0.181
3	48.930±0.161	2.389±0.113	4.882±0.230
4	54.710±0.177	2.620±0.124	4.789±0.226
5	49.510±0.191	2.773±0.134	5.601±0.270
6	51.430±0.157	2.321±0.109	4.513±0.213
7	51.953±0.144	4.065±0.102	7.824±0.195
8	58.718±0.132	2.785±0.094	4.743±0.160
9	47.879±0.080	2.310±0.057	4.631±0.114
10	44.342±0.129	2.680±0.091	5.818±0.198
11	68.697±0.325	6.736±0.228	7.349±0.249
12	52.477±0.186	3.839±0.132	7.316±0.252
13	47.216±0.086	3.223±0.061	6 827±0.129
14	60.080±0.231	5.684±0.163	7.247±0.208
15	56.526±0.372	5.432±0.262	9.610±0.463
16	50.584±0.121	3.239±0.085	6.403±0.168
17	52.924±0.132	4.352±0.093	8.223±0.176
18	52.455±0.211	4.635±0.149	8.836±0.284
19	65.953±0.355	6.450±0.251	9.780±0.381
20	72.618±0.364	6.471±0.257	8.925±0.354
21	77.568±0.651	6.401±0.459	8.252±0.592
22	85.732±0.497	7.803±0.351	8.102±0.364
23	70.706±0.203	5.422±0.142	7.668±0.201
24	86.025±0.283	5.957±0.201	6.925±0.234
25	97.000±1.214	9.718±0.874	10.019±0.910

The mean of the number of stamens in various stocks ranges between 44.342 ± 0.129 and 97.000 ± 1.214, most of them being 51—52 or near them. The stamens seem to develop according to certain definite schemes in association with the ontogeny of the petals, the determination of this from statistical investigation however is not practicable. Standard deviation also varies with the stock, but the coefficient of variability shows relatively smaller deviation compared with that obtained for the number of petals.

Petalody and Petalomany.

The double flowers of various plant species include many different types, and some authors have collected a remarkable number of instances of them, which they have classified under certain forms (MASTERS 1869, PENZIG 1890–4, GOEBEL 1898, WORSDELL 1915–6, SHIRAI 1925). The most common type of double flowers is the petalody, surplus petals being produced by change of stamens. In such flowers partially changing stamens occur very frequently, exhibiting all transmitting gradations. The double flowers of *Prunus Mume* sometimes or often contain such petaloid stamens or imperfect petals. In stocks 9 and 10, deformed petals (Pl. XI, fig. 3, and Fig. 5) occur very frequently. The rate of their occurrence in the total

Fig. 5. Deformed petals, showing various gradations of petalody (from stock 9, Sabashibeni).

surplus petals is 86.19 percent in stock 9. In stocks 7 and 8, the frequency is reduced to about one-half, 47.74 percent and 37.43 percent respectively. In contrast with these, stocks 12 and 13 contain only small proportions of deformed petals; namely, 4.11 percent and 1.91 percent respectively. From these results it may be be concluded that the semi-double stocks show a high rate of deformed petals due to petalody, whereas their ratio in duplicated types is generally low. The factors for increase of petals in this plant are both petalody and petalomany. For petalomany, I have cleared up the mode of

mechanism of duplication. Whereas petalody frequently resulte in deformed petals, petalomany generally produced perfect petals The basic petals of the flowers are always perfect in form: com plete duplication also results in perfect petals. The number of de formed petals is an index of petalody; while their absence or rarit in the double flowers is closely connected with petalomany in th occurrence of surplus petals.

An analysis of the double flowers will now be attempted b studying the correlation coefficient between the numbers of petal and stamens. Their correlation tables for 16 stocks are shown i the appendix. Some stocks gave negative correlation and other positive; increase in petals diminishing the stamens in the forme but increasing the stamens in the latter. The chief factor in nega tive correlation is the petalody of stamens, while that for positiv correlation is the duplication of petals. In stock 7, negative correl tion is relatively conspicuous (-0.301 ± 0.048), it being still mor evident in stocks 9 and 10, in which the coefficient values are -0.54 ± 0.037 and -0.508 ± 0.053 respectively. As pointed out alread these stocks include many deformed petals due to petalody. It i clear that petalody played the chief rôle in the increase of peta in these stocks. As far as has been tested, all semi-double stock showed negative correlation, so that in these flowers incomplete du plication or individual petalomany is not common; if anything it i rather rare. Except in two cases, more advanced double flower however showed positive correlation. In stocks 15 and 24, the corr lation coefficient is $+0.410 \pm 0.084$ and $+0.299 \pm 0.064$ respectivel evidently showing relatively high positive correlation. In NOHARA' cases, it was $+0.326 \pm 0.040$ in Kôrai and $+0.476 \pm 0.035$ in Mat sima. Here duplication was the main factor in the increase of petal

Thus, petalody naturally reduces the number of stamens: peta omany, or duplication, increases them by aiding in their productio Practically, however, limitation to space in the receptacles interfer with the increase of stamens. Petalody, itself, diminishes the numb of stamens, but at the same time it seems to stimulate the develo ment of the stamens, providing a basis for their production. Sin in double flowers, these factors work and interfere with each oth in the production of surplus petals and stamens, analysis of th correlation coefficients is greatly complicated. SAX (1918) studie the petaloid double flowers of *Chelidonium* and found that increas

in the number of petals reduces that of the stamens, that is, "a high negative correlation between petal number and stamen number." Prior to him, MIYOSHI (1912) observed a similar relation in *Deutzia*, while PEARSON *et al.* (1903) obtained pcsitive corretations in *Ranunculus*.

Flowers with Extra Sepals.

Flowers with extra sepals generally accompany increased number of petals and stamens, as may be seen in Table VI. This is the reason why I have excluded flowers with extra sepals in constructing

TABLE VI.

Statistical data for 6 sepals.

Stock No.	Number of sepals	For petals		For stamens		r
		M	σ	M	σ	
Stock 8	With 5 sepals	6.525	1.346	58.718	2.785	−0.177
	With 6 sepals	6.614	0.891	62.325	2.936	−0.023
Stock 13	With 5 sepals	15.710	1.106	47.216	3.223	+0.205
	With 6 sepals	18.198	1.188	50.099	2.905	+0.235
Stock 16	With 5 sepals	17.778	2.406	50.584	3.239	−0.196
	With 6 sepals	19.435	1.637	52.841	3.475	−0.128

the general tables. Increase of sepals does not influence the correlation coefficients.

Some statistical treatment of surplus pistils, which frequently occur in double flowers, was attempted, but no facts worth reporting here were found.

Summary.

The nature of doubling in the flower of *Prunus Mume* is considered, with special bearing on the mode of duplication of petals. Petalomany occurs in definite schemes with different degrees of primary, secondary, and tertiary duplications, with their imperfect stages.

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EXPLANATION OF PLATE XI.

Fig. 1. Single flowers (Bungo).

Fig. 2. Double flowers forming primary duplication, with fluctuations around the mode at 15 (stock 11, Hakubotan).

Fig. 3. Semi-double flowers, due mainly to petalody (stock 10).

Fig. 4. Double flowers forming complete primary duplication (stock 12).

Fig. 5. Double flowers forming secondary duplication (stock 23, Naniwa).

Appendix: Correlation Tables.

The correlations between the numbers of petals and stamens in 16 stocks are given in the following tables. Stocks showing only small variation, or those tested with only a small number of samples, were omitted in the construction of these tables. In the tables, class Y indicates the number of petals and class X that of stamens. The mean, the standard deviation, and the correlation coefficient of the number of petals are shown in ruby type y and those for the number of stamens in ruby type x.

TABLE VII.

Correlation in stock 6 (5 sepals).

Y \ X	45	46	47	48	49	50	51	52	53	54	55	56	57	58	Total
5	1	2	1	2	7	15	11	22	16	3	4		2	2	88
6			1	1	1		1	1	1						6
7				1		1	1	2							5
8								1							1
Total	1	2	2	4	8	16	13	26	17	3	4		2	2	100

$M_y = 5.190 \pm 0.038$ $M_x = 51.430 \pm 0.157$

$\sigma_y = \pm 0.560 \pm 0.026$ $\sigma_x = \pm 2.321 \pm 0.109$

$\gamma = -0.117 \pm 0.099$

TABLE VIII.

Correlation in stock 7 (5 sepals).

Y \ X	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	Total
5	1		1	2	2	3	3	4	10	16	17	22	32	17	21	18	8	3	11	1			1		1	194
6			5		4	2	2	5	5	6	10	11	8	5	3	6	1	2	2	1						78
7		2	3		3	2	3	5	4	3	7	6	5	6	4	2	2		1		1	1				60
8				1	1	2	1		4	2			1	2	1	1						1				17
9			1	1		1		2	1		2			2		1										11
10		1		1		1																				3
Total	1	3	10	5	10	11	9	16	24	27	36	39	46	32	29	28	11	5	14	2	1	2	1		1	363

$M_y = 5.871 \pm 0.041$ $M_x = 51.953 \pm 0.144$

$\sigma_y = \pm 1.148 \pm 0.029$ $\sigma_x = \pm 4.065 \pm 0.102$

$\gamma = -0.301 \pm 0.048$

TABLE IX.

Correlation in stock 8 (5 sepals).

Y \ X	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Total
5							2	3	2	9	12	8	6	11	5	2	4		1	65
6						1			3	4	11	7	4	2		2	1	1		36
7				1	1		2	6	3	5	7	3	5	8	7	2		1		51
8								5	4	7	5	3	4	2	2	1				33
9	1				1				2		4	1	1		3		1			14
10							1				1		1							3
Total	1			1	2	1	5	14	14	25	40	22	21	23	17	7	6	2	1	202

$M_y = 6.525 \pm 0.064$ $M_x = 58.718 \pm 0.132$

$\sigma_y = \pm 1.346 \pm 0.045$ $\sigma_x = \pm 2.785 \pm 0.094$

$\gamma = -0.177 \pm 0.068$

TABLE X.

Correlation in stock 8 (6 sepals).

Y \ X	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	Total
6	1			3	2	1	11	10	8	8	6	8	5	1	3				1	68
7				1			4	6	3	4	4	1		1						24
8				3		2		3	5	1	3			1	2					20
9								1							1					2
Total	1			7	2	3	15	20	16	13	13	9	5	3	6				1	114

$M_y = 6.614 \pm 0.056$ $M_x = 62.325 \pm 0.185$

$\sigma_y = \pm 0.891 \pm 0.040$ $\sigma_x = \pm 2.936 \pm 0.132$

$\gamma = -0.023 \pm 0.093$

TABLE XI.

Correlation in stock 9 (Sabashibeni, 5 sepals).

Y \ X	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	Total
5		1				2	2	2	3	2	11	8	3	1		35
6				1	1	1	1	4	8	15	10	8	2	1	1	53
7	1			1	2	4	6	14	29	25	12	8	4	1	1	108
8	1	1		1		1	8	17	18	13	5	2	1			68
9				2	5	4	13	13	12	10	3	2	1			65
10		1				4	7	4	3	1	2	1				23
11			1		4	6	7	1	1							20
12				2	2	2										6
13																0
14		1														1
Total	2	4	1	7	14	24	44	55	74	66	43	29	11	3	2	379

$M_y = 7.689 \pm 0.058$ $M_x = 47.879 \pm 0.080$

$\sigma_y = \pm 1.676 \pm 0.041$ $\sigma_x = \pm 2.310 \pm 0.057$

$r = -0.540 \pm 0.037$

TABLE XII.

Correlation in stock 10 (5 sepals).

Y \ X	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Total
5														1	1
6								1	1		2	2	5		11
7			1		1		2	4	2	1	5	8	2		26
8			1	2	3	3		1	2	4	8	3			27
9				1	2	3	3	2	8	11	4	1	1		36
10			1	1	2		4	5	10	8	1				32
11		1		2	4	3	7	6	6	3		1			33
12		1	1			2	6	4	1						15
13				2	2	2									6
14	1	1		2	2		2	1							9
Total	1	3	4	10	16	13	24	24	30	27	20	15	8	1	196

$M_y = 9.505 \pm 0.098$ $M_x = 44.342 \pm 0.129$

$\sigma_y = \pm 2.040 \pm 0.069$ $\sigma_x = \pm 2.680 \pm 0.091$

$r = -0.508 \pm 0.053$

TABLE XIII.

Correlation in stock 11 (Hakubotan, 5 sepals).

Y \ X	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	Total
12										1																											1
13			1										1	1				1																			4
14	1			2	1		1	2	1	3		2	2		3	3	1	1	3		2					2											39
15		2		1	2	3	2	3	3	5	3	6	4	5	3	6	7	8	4	7		4	7	4	7	1	2	1	1	2	2	1				1	107
16	1							2		1		2	5	2	2	2	3	5	2	4		4	1	1		1		1	1								40
17												1				1		1				2			1	1	1	1									9
18												1		1			1																				3
19															1		1					2															4
Total	2	2	1	3	3	3	3	7	4	10	3	12	12	9	9	12	13	16	9	11	2	12	8	5	8	5	3	3	2	2	2	1				1	198

$M_y = 15.212 \pm 0.050$ $M_x = 68.697 \pm 0.325$

$\sigma_y = \pm 1.037 \pm 0.035$ $\sigma_x = \pm 6.736 \pm 0.223$

$r = +0.199 \pm 0.069$

TABLE XVII.

Correlation in stock 14 (Tamashibori, 5 sepals).

Y \ X	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	Total
15	3	3	2	4	2	5	9	9	13	8	9	4	6	10	7	10	7	8	2	5	4		3	3		2						138
16			1	1	2	1	2	3	4	4	4	4	2	4	4	4	5	8	2	4	1	3	3		1							67
17		1	2			3		2	2	2	3	7	1		3	4	5	1	2		1			1							1	41
18			1	1	2		2	1		1		1	1	2	1	2		2			2		1									20
19											1	1								1		1										4
20							2		1								1	1														5
Total	3	4	6	6	6	9	15	15	20	15	17	17	10	16	15	20	18	20	6	10	8	4	7	4	1	2					1	275

$M_y = 15.909 \pm 0.047$ $M_x = 60.080 \pm 0.231$

$\sigma_y = \pm 1.164 \pm 0.033$ $\sigma_x = \pm 5.684 \pm 0.163$

$r = +0.043 \pm 0.060$

Table XIV.

Correlation in stock 12 (5 sepals).

Y \ X	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	Total
15	1	3	4	6	14	11	7	10	22	10	10	9	4	8	1	2		1			1		124
16					1	1	4	2	4	3	7		4	3	2	2	1		1				35
17				1	1	1	1	3	3	1	1	1	2			2				1			18
18						2	1	1	1	1	1	1		1	1							1	11
19										1				1									2
20						1																	1
21													1					1					2
Total	1	3	4	7	16	16	13	16	30	16	19	11	11	13	4	6	1	2	1	1	1	1	193

$M_y = 15.668 \pm 0.055$ $M_x = 52.477 \pm 0.186$

$\sigma_y = \pm 1.131 \pm 0.039$ $\sigma_x = \pm 3.839 \pm 0.132$

$r = +0.200 \pm 0.069$

Table XV.

Correlation in stock 13 (5 sepals).

Y \ X	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	Total
14																					1						1
15	1				1		1	3	14	16	25	35	41	35	42	45	36	37	28	9	4	1					374
16				1					3	7	6	4	11	17	16	19	18	18	11	3	4	1					139
17							1	1		1		4	4	9	9	9	9	9	11	5	3		1			1	77
18									1		1	2	1	5	1	1	4	5	5	4	3						33
19																1	1	1					1				4
20										1								1		1							3
21																											0
22												1					1						1				3
23															1												1
Total	1			1	1		2	4	18	25	32	46	57	66	69	75	69	71	55	22	15	2	3			1	635

$M_y = 15.710 \pm 0.030$ $M_x = 47.216 \pm 0.086$

$\sigma_y = \pm 1.106 \pm 0.021$ $\sigma_x = \pm 3.223 \pm 0.061$

$r = +0.205 \pm 0.023$

TABLE XVI.

Correlation in stock 13 (6 sepals).

Y \ X	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	Total
13					1														1
14							1												1
15										1									1
16					1	1			1			1							4
17					1			1	1	1	1	2					1		8
18	1		2		2	3	4	11	8	12	12	10	4	5		1	1		76
19					1		3	1	3	6	5	2	4	2		2			29
20						1		1		1	2		2						7
21												1						1	2
22											1								1
23										1									1
Total	1		2		6	5	8	14	13	22	21	16	10	7		3	2	1	131

$M_y = 18.198 \pm 0.070$ $M_x = 50.099 \pm 0.172$

$\sigma_y = \pm 1.188 \pm 0.050$ $\sigma_x = \pm 2.905 \pm 0.121$

$r = +0.235 \pm 0.039$

TABLE XVIII.

Correlation in stock 15 (5 sepals).

Y \ X	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	78	Total
14									1																		1
15	3				2	3	1		1	5	3	2	2	3	3	2	1			2	2						35
16						1	1	1		1	1	2	3	7	2	2		2	2	3		1	1			1	31
17							1						1	2	2		1	3	1	1	2	2	1		1		18
18												1					2			1			2				6
19										1					1			1					1				4
20														1				1									2
Total	3				2	4	3	1	2	7	4	5	6	13	8	4	4	7	3	7	4	3	5		1	1	97

$M_y = 16.134 \pm 0.085$ $M_x = 56.526 \pm 0.372$

$\sigma_y = \pm 1.236 \pm 0.060$ $\sigma_x = \pm 5.432 \pm 0.262$

$r = +0.410 \pm 0.084$

TABLE XIX.

Correlation in stock 16 (5 sepals).

Y \ X	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	Total
15			1	2	1	9	5	3	9	12	9	7	6	4	1					69
16					2	5	7	1	8	5	7	7	3	6	1	2	1	1		56
17			1		3	3	3	6	2	5	7	5	2	2	2	1			1	43
18		1		2	1	2	4	5	6	5	6	7	3	1	1			1		45
19	1	1		1	2	3	1	4	5	7	7	5	1	2	2					42
20	1			1		3	1	3	5	4	2	4	2	2	1	1				30
21	1	1	1	1	1	1	2	1	2	2		3				1				17
22		1	1				1	3	1	1	1	1			1					11
23				1	2		2				1		1		1					8
24			1	1			1	1		1										5
25					1						1									2
26										1										1
Total	3	4	5	9	13	26	27	27	38	43	41	39	18	17	10	5	1	2	1	329

$M_y = 17.778 \pm 0.090$ $M_x = 50.584 \pm 0.121$

$\sigma_y = \pm 2.406 \pm 0.063$ $\sigma_x = \pm 3.239 \pm 0.085$

$\gamma = -0.196 \pm 0.053$

TARLE XX.

Correlation in stock 16 (6 sepals).

Y \ X	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	Total
17										1						1					2
18	1						1	1	4	6	4	1	3	2	2	2			1	1	29
19						1	1		1			4	2	3	1	2					15
20					1				1					2			1				5
21								1		1	1	1	1		3	1		1			10
22											1										1
23								1						1							2
24						2				1		1									4
25																					0
26											1										1
Total	1				1	3	2	3	6	9	7	7	6	8	6	6	1	1	1	1	69

$M_y = 19.435 \pm 0.133$ $M_x = 52.841 \pm 0.282$

$\sigma_y = \pm 1.637 \pm 0.094$ $\sigma_x = \pm 3.475 \pm 0.200$

$\gamma = -0.128 \pm 0.119$

TABLE XXI.

Correlation in stock 17 (5 sepals).

Y \ X	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	Total
15						1	1	3		1	4	2	2	2		2		2	1	2	1	1							25
16	1				1	1	2	4	2	6	2	6	3	9	3	11	5	6	1	1	1	3			1				69
17		1		1			1	4	5	8	7	12	9	6	6	10	5	3	8	3	5	1	1	2				1	99
18			2		2	2	1	5	5	9	11	9	10	8	7	9	8	7	7	3	1	1	1						108
19				1	1	3	2	6	7	5	4	8	9	7	5	9	5	12	6	4	1	1	1	1					98
20							1	2		6	5	3	3	6	8	4	2	5	1	2			1		1				50
21		1						1	2	3	2	7	3	1		3	4	2		2	3		1						35
22					1					1		1	1	1	1		1						1						8
23									1						1			1				1							4
24																													0
25																1													1
Total	1	2	2	2	5	7	8	25	22	40	35	48	40	40	31	48	30	38	24	17	12	8	6	3	2			1	497

$M_y = 18.101 \pm 0.052$ $M_x = 52.924 \pm 0.132$

$\sigma_y = \pm 1.729 \pm 0.037$ $\sigma_x = \pm 4.352 \pm 0.093$

$\gamma = +0.027 \pm 0.045$

TABLE XXII.

Correlation in stock 18 (5 sepals).

Y \ X	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Total
15											1						1												2
16								2		1	1																		4
17						1			2		1	1	1			1	1		1	1					1				11
18										1		1		3	1	2	3	1	1	1		1							15
19							1			3	1	4	1	3	2	3	1	2				1							22
20							1		3	3	1	3	3	3	2	1	2	8		2	1		1	1		1			36
21			2		2	1			2	1	2	4	3	2	4	4	1	2	3	3	2		2	1					41
22								1	2		2	3	4	5	2	2	2	4	1									1	29
23							2	1	2	1	1	1	1	1	3	2	5	2	2	1		1							26
24					1	1					1	3	2		1			1		2		2	1						15
25	1							1		2		2				4	1	1					1						13
26					1	1										1	1												4
27																													0
28									1										1										2
Total	1		2		4	4	4	5	12	12	11	22	15	17	15	20	18	21	9	10	3	5	5	2	1	1		1	220

$M_y = 21.050 \pm 0.110$ $M_x = 52.455 \pm 0.211$

$\sigma_y = \pm 2.413 \pm 0.077$ $\sigma_x = \pm 4.635 \pm 0.149$

$\gamma = -0.019 \pm 0.068$

TABLE XXIII.

Correlation in stock 19 (5 sepals).

Y \ X	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	Total
16																	1	1			1	1	1							5
17								2	1				1			1														5
18						1		1								1									1					4
19	1						1				1	1					5		1											10
20		3									1		1				1	1	1		1	1	1							11
21											2		1				1	1			1	2	1	1						10
22					1			1			1	1	1	1	2	2	4	4					1			1		1		21
23		1	1	1	1	2		1		2	1						2		3		2	2	1				1			21
24									1	1		1		1	2	2	2			1		1						1	1	14
25									1		1	1		2	1	1				2	1		1	1	1				1	14
26	1								4		2		1			1	1				1	2	1							14
27												1		1			1		1				2					1		7
28													1							1	1				2					5
29				1								1		1				1												4
30																			1		2	1			1					5
Total	2	4	1	2	2	3	1	5	7	3	9	6	6	6	5	8	18	8	7	4	10	10	9	2	5	1	1	3	2	150

$M_y = 22.980 \pm 0.183$ $M_x = 65.953 \pm 0.355$

$\sigma_y = \pm 3.334 \pm 0.130$ $\sigma_x = \pm 6.450 \pm 0.251$

$r = +0.010 \pm 0.082$

TABLE XXIV.

Correlation in stock 23 (Naniwa, 5 sepals).

Y \ X	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	Total
23										1																		1
24																		1		1		1						3
25				1	1	1		1		3				1	3							2					1	14
26			1	1				2	2			2	2	2	4	2			1	2	1		2		1			25
27	1	1			2		1	4			3	2	2		1	2	4		2	1	1		2				1	30
28			1			2		1	2	5	5	3	3	5	3	2	2	2	4	2	3	5			3	1		54
29					1	1	1		2	3	3		5	4	4	8	2	2	3	3	1	4	3	1	1		1	53
30				1		1	2		2	1	3	5	4	3	7	8	2	2	3	2	1	2	1	1	1	2		54
31				1			1		1		2	1	1	3	6	7	1	2	3	1	2	3	2	2	2	1		42
32												2	2	2	4	3	3	2	1	2	1				1	2		25
33							2		1		1				1		1	1	1	2	2		2			1		15
34										1			1	1	2			1	1									7
35																2						1				1	1	5
36																					1		1					2
Total	1	1	2	4	4	5	7	8	10	14	17	15	20	21	35	34	15	13	19	16	13	18	13	4	9	8	4	330

$M_y = 29.261 \pm 0.089$ $M_x = 70.706 \pm 0.203$

$\sigma_y = \pm 2.370 \pm 0.062$ $\sigma_x = \pm 5.422 \pm 0.142$

$r = +0.211 \pm 0.053$

TABLE XXV.

Correlation in stock 24 (5 sepals).

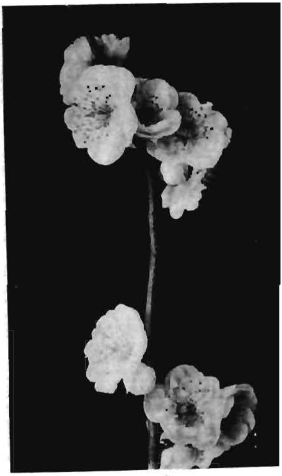
Y \ X	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	Total
21							1																												1
22																																			0
23																					1														1
24																		1																	1
25	1																																		1
26		1							2							1																			4
27						1					1				1																				3
28							1				1			2	1		3	1	1	1					1										12
29				1			1	1	3	2		3	4	5	1	1	1	2	2	1		1	1	1	1		2								34
30					2	2	1	3	4	2	3	2	2	3	3	3	3	3	6	1	1	1	1			1		1	1						49
31			1			2		1		1	2	3	2	5	3	4	1	4		4		1	5		1							1			41
32						1					1			1	2	1	4	2	4	1	5	1	1				2			1					27
33												1		1		2	1	1	2	1	1	1				2		1							14
34								1						1		1	1		1																5
35													1							1				1		1									4
36																																		1	1
37											1																								1
38																					1														1
Total	1	1	1	1	2	6	4	6	9	5	9	9	9	18	11	13	14	14	16	10	9	5	8	2	3	4	4	2	1	1		1		1	200

$M_y = 30.440 \pm 0.103$ $M_x = 86.025 \pm 0.283$

$\sigma_y = \pm 2.156 \pm 0.073$ $\sigma_x = \pm 5.957 \pm 0.201$

$r = +0.299 \pm 0.064$

1



2

Some Remarks on Fasciation of Pharbitis Nil.

By

Yoshitaka Imai and **Benso Kanna.**

With one Text-figure.

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Introduction.

Fasciated strain in the Japanese morning glory, *Pharbitis Nil*, has long been known in Japan, where it was described and pictured about 120 years ago (cf. IMAI 1927). The genetics of fasciation in this plant was investigated by HAGIWARA (1924, 1926), IMAI (1926, 1927, 1930b), and YAMAGUCHI (1926a, 1926b). According to IMAI, this stem abnormality is expressed by three polymeric recessive genes, fasciated-1, fasciated-2, and fasciated-3. The locations of the genes are as follows: both fasciated-1 and fasciated-2 in the pear chromosome and fasciated-3 in the variegated chromosome (IMAI 1927, 1933).

Occurrence of Temporary Fasciation.

Fasciation occurs widely in many plants, including herbs, shrubs, trees, and even in some fungi (MASTERS 1869, PENZIG 1890–4,

WORSDELL 1915–6, WHITE 1916, SHIRAI 1925). Its existence is generally *temporary, having been caused either by certain environmental* influences or by accident. Under certain environmental conditions, the various plant species or strains are predisposed to fasciation in response to these influences.

Physiological or temporary fasciation does not transmit the abnormality to their progeny. Such fasciation has not yet been observed in the Japanese morning glory (IMAI 1927), all fasciation so far observed being hereditary. The writers recently obtained two specimens showing fasciation to a considerable degree in a pedigree culture originally unconnected with heritable fasciation. These fasciated plants bred true to normal in the offspring. Two similar non-hereditary cases have been reported to the writers by cultivators. The writers sowed seeds, both of a fasciated branch and of normal branches of a normal plant, sent by another cultivator, but the flattened stem character did not transmit to the offspring. These physiological forms bore normal leaves. In this plant therefore we have temporary fasciation due to stimulation from certain environmental factors. The occurrence however being rare, the tendency to fasciation is relatively speaking very weak in this plant.

The Polymeric Genes.

In the Japanese morning glory, IMAI (1927) analyzed three polymeric recessive genes for fasciation. New F_2 data obtained by crossing fasciated with normal are presented in Table I.

TABLE I.

F_2 from crossing of pear fasciated with normal.

Cross	Normal	Pear	Fasciated	Pear fasciated	Total	% of fasciated
SW×NF	268	84	0	12	364	3.30
415×NF	170	47	3	11	231	6.06
SU×NF	254	45	1	8	308	2.92
356×NF	141	40	0	7	188	3.72
9T×NF	154	41	1	4	180	2.78
190×NF	132	32	0	5	169	2.96
220×NF	59	17	0	3	79	3.80
M3×NF	130	31	0	4	165	2.42
ID×NF	108	29	0	4	141	2.84
SK6×NF	116	26	0	3	145	2.07
N2×WF	94	38	0	2	134	1.49
RF×IF	43	18	0	6	67	8.96
RF×WF	204	44	0	13	261	4.98
435×IF	41	11	0	4	56	7.14
Total	1894	503	5	86	2488	3.66

The frequency of fasciated segregates runs from 1.49 to 8.96 percent. In a previous paper, IMAI gave the F_2 results of six crosses, in which the fasciated segregates varied from zero to 2.97 percent. From progeny tests of a cross, in F_2 of which 2.97 percent of the fasciated segregates were obtained, IMAI analyzed three polymeric genes for fasciation. The segregating ratio is modified by the linkage between fasciated genes and by the fluctuation in the manifestation of fasciation. Since the extent of the fluctuation differs in the different strains, it is dificult to know from the segregating ratio in F_2 the number of genes responsible for fasciation in a given cross. In some cases with a low percentage of fasciated segregates, the number of genes responsible for the fasciation complex seems to be more than three, or there are one or more modifiers at work (IMAI 1927). There exist, of course, normals having one or two sets of normal (non-fasciated) allelomorphs. When such normals are crossed with fasciated we should obtain monogenic or digenic segregation in the hybrid progeny. The data obtained by HAGIWARA (1924, 1926) and YAMAGUCHI (1926a) include duplicate genes in the production of fasciation. In a backcross experiment, IMAI (1933) detected two fasciated genes (fasciated-1 and fasciated-3). By backcrossing parental fasciated with an F_1, the segregation that occurred in the offspring was 215 normal and 74 fasciated, or 25.6 percent fasciated. In crossing fasciated with pear-leaved normal, the writers obtained the simple results as shown in Table II.

TABLE II.

F_2 from crossing of pear fasciated with pear.

Cross	Pear	Pear fasciated	Total	% of fasciated
SK×WF	59	21	80	26.25
SK×DF	82	32	114	28.07
Total	141	53	194	27.32

The segregation is monogenic for fasciation. In Table III are indicated new backcross data proving digenic segregation.

TABLE III.

Backcross: (normal × pear fasciated) × pear fasciated.

Backcross	Normal	Pear	Fasciated	Pear fasciated	Total	% of fasciated
(RF×IF)×IF	60	36	0	31	127	24.41
(RF×WF)×IF	120	70	0	46	236	19.49
(435×IF)×IF	47	23	0	11	81	13.58
Total	227	129	0	88	444	19.82

The backcross experiments revealed the fact that the normal parents in these crosses have two sets of normal allelomorphs for fasciated-1 and fasciated-3. The corresponding F_2 shown in Table I gave for fasciated segregates 8.96 percent, 4.98 percent, and 7.14 percent respectively. These figures are much higher than the 2.89 percent for cross 326×A5, in which segregation was trigenic.

The subject of hereditary fasciation of plants is fortunate in the abundance of genetic literature. The main genetic literature on fasciation are the works of MENDEL (1865) and others (cf. WELLENSIEK 1925) on *Pisum*; EAST and HAYES (1911), and EMERSON (1912) on *Zea*; WHITE (1916) on *Nicotiana*; STOUT (1918) on *Cichorium*; LLOYD (1918) on *Gossypium*; BAUR (1924) on *Antirrhinum*; COLLINS (1924) on *Crepis*; NAGAI (1926) and TAKAGI (1929) on *Glycine*; KELLY (1927) on *Phlox*; SHULL (1929) on *Capsella*; NOHARA (1933) on *Sesamum*; KANNA (unpublished data) on *Impatiens*; and others. Generally, fasciation is monogenically recessive to normal, but in a few cases such as EAST and HAYES' *Zea*, WHITE's *Nicotiana*, STOUT's *Cichorium*, and LLOYD's *Gossypium*, the abnormality is transmitted as dominant. In some cases, the genetics is of a more complicated nature, not yet fully worked out. SHULL however identified two recessive genes responsible for fasciation. NOHARA, in studying *Sesamum*, came to the conclusion that in his first series of experiments, duplicate recessive genes were concerned in the manifestation of monstrosity. His data, however, on the basis of which he drew the above conclusion, may not be sufficient to be conclusive. In the writers' opinion, the deficit of fasciated segregates in the hybrid progeny may be attributed to manifestation of fluctuation in the fasciation, seeing that his fasciated stocks frequently give normal atavists.

Crypto-fasciation.

In some cases the fasciation bred true or almost true to type in the offspring, but in others it was mixed with a few or many normals. Such normals, when selfed, give rise to many fasciations, showing the normals to be false or crypto-fasciated. DE VRIES (1901–3) and other investigators were fully aware of the occurrence of such normal atavists in certain fasciated plants. This means that the fasciation at times fails in its manifestation through environmental influences. In *Pharbitis*, the fasciation is affected in its expression by environmental factors, frequently giving rise to crypto-fasciated (IMAI 1927, 1930b). Fasciated *Sesamum* (NOHARA 1933) also throws out many normal atavists. For such normals, NOHARA, while partly admitting his failure in correctly diagnosing fasciation, still attributed some of the cases to "Rückmutation" from fasciated to normal, without any reliable genetic basis. It seems more natural to regard them as crypto-fasciated or false normals.

Although frequency in the occurrence of the crypto-fasciated in the fasciated *Pharbitis* may be influenced by environmental factors, yet the stocks show roughly definite average proportions, which differ in different pedigrees (IMAI 1927). These two fasciated strains of different origin were observed for three successive years in order to examine the rate of occurrence of crypto-fasciated. Table IV summarizes the data obtained.

TABLE IV.

Proportion of crypto-fasciated in two fasciated strains.

Year	Strain DF				Strain WF			
	Normal	Fasciated	Total	% of fasciated	Normal	Fasciated	Total	% of fasciated
1930	3	66	69	4.35	17	100	117	14.53
1931	13	151	164	7.93	18	82	100	18.00
1932	10	182	192	5.21	20	136	156	12.82
Total	26	399	425	6.12	55	318	373	14.75

These two strains of commercial origin have been bred by pedigree culture for several years before we made tests. Strain DF produced a smaller percentage (6.12%) of the crypto-fasciated than

strain WF (14.75%), that is, the latter is more unstable in the manifestation of the fasciated character than the former. The degree of stem flattening is more conspicuous in strain DF. Thus the two strains have nearly definite but somewhat variable rates for producing crypto-fasciated. There are more fluctuating strains in which the extent to which false manifestation may occur has a much wider variation. Fasciated strain A5 that was used in IMAI's experiments (1927) bred almost true to fasciated. This strain was lost before further tests could be made. YAMAGUCHI's stock (1926a) also had a high constancy. The difference in rate of occurrence of the crypto-fasciated implies the presence of certain genic modifiers that qualify the frequency and possibly also the average degree of stem flattening.

The crypto-fasciated, when selfed, gave rise to many fasciated in the offspring, with reappearance of some normal atavists (IMAI 1927, 1930b). The four crypto-fasciated that appeared in strain WF produced 10 normal and 52 fasciated; that is, the frequency of normals is 16.13 percent, nearly agreeing with that obtained by selfing the fasciated (14.75%).

The fasciated *Pharbitis* frequently put forth normal branches. These branches are also produced by mere fluctuation. Tests made by the writers showed the following results: The seeds collected from the normal branches gave 10 normal and 40 fasciated, whereas those from fasciated stems of the same individuals produced 6 normal and 24 fasciated, the frequency of normal being 20 percent in both cases, thus proving the manifestation of fluctuation.

The Non-pear Fasciated Segregates.

Heritable fasciation of *Pharbitis* always accompanies pear leaves. Pear is a simple recessive leaf character (cf. IMAI 1930a). YAMAGUCHI (1926a, 1926b) observed the break in the combination between pear and fasciated, and estimated the recombination frequency to be about 4 or 5 percent. From his own data, IMAI (1927) calculated the recombination for pear and fasciated-1 to be about 2.5 percent. Neither author made any attempts to breed the non-pear fasciated that were regarded as crossovers. The writers made good this gap with experiments. They selfed three non-pear fasciated segregates (Fig. 1) but obtained practically no non-pear fasciated

in the offspring. One of them gave only normals for two genera-

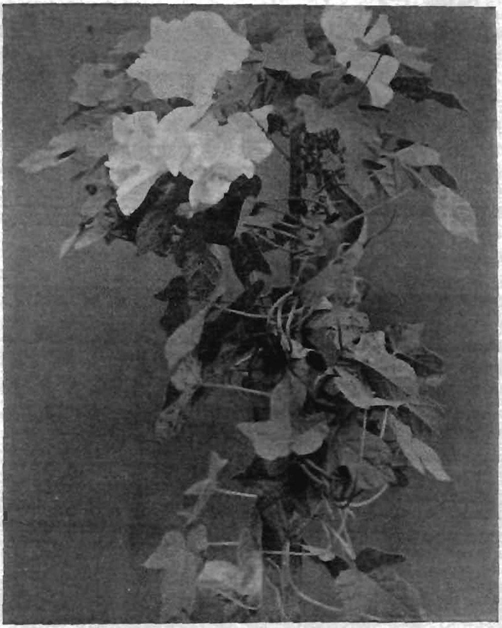

Fig. 1. Non-pear fasciated segregate.

tions. The other two segregated out some pear fasciated, but with the exception of one individual which was non-pear fasciated like the grand-mother, gave no non-pear fasciated during two generations. What is the criteria of these breeding results? It seems probable that *these non-pear fasciated segregates are not crossovers* between pear and fasciated-1, but only temporary fasciation with normal leaves, caused by environmental influences. If we sum up

all the non-pear fasciated segregates in the data available for F_2, including those published by IMAI (1927), the frequency in the total normal (non-fasciated) is 0.24 percent. This figure, though very small, seems much greater when it is compared with frequency in the occurrence of false fasciated in the pure normal pedigrees. This difference may be due partly to the genic modifiers and partly to the condition heterozygous for fasciation.

For the writers to draw final conclusions after having examined only three non-pear fasciated segregates might seem somewhat premature, but from all that is known at present they feel it permissible to say that the pear-fasciated characters are either linked together by a very rare recombination (less than 2.5 percent) or that they are due to the manifold effects of one and the same gene. HAGIWARA (1924, 1926) held the latter view, because he failed to obtain such segregates in his hybrid progeny owing to the small number tested. In backcrossing the fasciated parent to F_1, IMAI obtained 134 normal, 81 pear, and 74 pear fasciated, without any non-pear fasciated, or a ratio of 2 : 1 : 1. This shows the strong combination of the two characters (pear and fasciated-1).

YAMAGUCHI (1926a) and IMAI (1927) gave instances of families in which the segregation was simplified to monogenic in the hybrid progeny. In Table V are presented new F_3 data showing such a segregation from cross $220 \times DF$, in which two genes are responsible for fasciation (IMAI 1933).

TABLE V.

F_3 from cross $220 \times DF$, showing monogenic segregation for fasciation.

Number of pedigrees	Normal	Pear	Fasciated	Pear fasciated	Total	% of fasciated
16	454	17	2	153	625	24.80

In these pedigrees the segregation is greatly simplified, giving monogenic segregation for fasciation (24.80 percent of recessives). Of these segregates, pear and non-pear fasciated may, at least partly, or mostly, be temporary manifestations of pear fasciated (in the former) and normal (in the latter). By backcrossing double recessive with F_1, obtained by the cross between fasciated with poly-celled ovary (double recessive) and normal (double dominant) of

Sesamum, NOHARA (1933) raised 143 normal, 59 polycelled, and 103 polycelled fasciated segregates. From these data he made an attempt to calculate the recombination frequency. In this backcross experiment, he however had no two-celled fasciated. With this exception, the case is apparently similar to that of *Pharbitis*. If any recombination were expected in *Sesamum*, the frequency would probably be very low. NOHARA made his estimate however by treating the data too arbitrarily and calculated a 16.07 percent recombination. In his backcross data, 59 polycelled segregates, at least the majority of them, may be considered to be genotypically polycelled fasciated. If all of them are so, the frequency in occurrence of the false normals in these fasciated segregates amounts to 36.42 percent!

Summary.

1. Temporary fasciation of the Japanese morning glory, caused by certain environmental influences, occurs in cultures unconnected with heritable fasciation. On selfing, they back to normal in their offspring.

2. Segregation of the fasciated in the hybrid progeny is either monogenic, digenic, or trigenic, according to differences in genotypes of their normal parents or of their heterozygous mother plants.

3. Crypto-fasciated occur in the pure fasciated pedigrees. They give rise to many fasciated in the offspring.

4. Thus mismanifestation occurs reversibly between normal and fasciation, the frequency being probably affected by genic modifiers.

5. So far as tested, the non-pear fasciated segregates in the hybrid progeny proved to be normal in their genotype. Therefore, the characters, pear and fasciated-1, are either linked together closely than hitherto supposed or they are manifested by one and the same gene.

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Genetic Studies in Impatiens Balsamina L.

By

Benso Kanna.

With Plate XII and one Text-figure.

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Introduction.

Several years ago I collected various strains of balsam from Japanese and foreign seedsmen, and with these strains began a series

of investigations, some of the results of which were published in my previous papers (KANNA 1926, 1927, 1933). In this paper I shall sum up these results, concluding with a discussion on the hereditary nature of the plant.

Balsam, *Impatiens Balsamina* L., is an annual plant, which is cultivated commonly for its variations in flower type, flower color, etc. RASMUSON (1920) published a brief paper that dealt with the inheritance of some morphological characters of the plant. His conclusions concerned the plant stature, flower color and its patterns, but he gave no numerical data regarding them. After that HAGIWARA (1926) reported his breeding results on doubling, flower color and its anthocyanin variegation. Our genetic knowledge of balsam has been greatly enriched by the work of these authors, with whose conclusions, however, I am not always in agreement.

I wish to express my hearty thanks to Professor KIICHI MIYAKE and Doctor YOSHITAKA IMAI for their valuable guidance and criticisms in the course of my experiments.

Flower Types.

The following four forms are recognizable as the standard flower types in balsam:

I. Normal. The development of the wing petals is incomplete (Pl. XII, Figs. 17 and 22), the whole appearance of the flower being that of restricted development.

II. Winged. The wing petals are fully developed (Pl. XII, Figs. 1—9, 11, 13—16 and 18—21).

III. Double. Doubling is due to petalody (Pl. XII, Figs. 1 and 5) or to petalomany (Pl. XII, Figs. 8, 17, 18 and 22), the identification of these two types being very difficult. The degree of petalody varies according to its genotype or to environmental conditions.

IV. Camellia. The flowers are doubled and the terminal ones are peloric double, due to complete or almost complete petalomany. The peloric doubles remind us of the flowers of some double varieties of camellia (Pl. XII, Figs. 6, 7 and 21). The plant is somewhat stunted in stature.

1. Winged Corolla.

When the normal and winged flowers are inter-crossed with themselves, we obtain the F_1 flowers with their own respective characteristics and in every case they breed true to type for generations. The F_1 plants obtained by crossing both types, however, invariably bear normal corollas, showing the recessiveness of the winged condition. In F_2, I obtained segregating data as shown in Table I.

TABLE I.

F_2 data of cross, winged × normal.

Cross number	Normal	Winged	Total
1	109	32	141
2	11	6	17
3	34	6	40
4	15	7	22
Total	169	51	220
Expected	165	55	220

Segregation occurred in a 3 : 1 ratio, which indicates monogenic difference in the production of the two types. Experiments on F_3 attempted with eleven F_2 plants resulted as shown in Table II.

TABLE II.

F_3 data of cross 1.

Character of F_2	Number of pedigrees	Normal	Winged	Total
Normal	2	103	—	103
	7	98	28	126
Winged	2	—	46	46

The gene for winged corolla will be represented by w_g in this paper.

2. Double Flowers.

Of two kinds of double flowers, petalody and petalomany, the

former breed true when inter-crossed, but it behaves as a recessive to single flower when a crossing is made. Owing to complete sterility of the petalomany, their subsequent generations could not be traced. The data presented in this paper, therefore, are for petalody classified into two types, "strong" for conspicuously petaloid flowers and "weak" for slightly petaloid.

From the single F_1 flowers, I bred a subsequent generation consisting of segregates as shown in Table III.

TABLE III.

F_2 data of cross, single × "strong" double.

Cross number	Single	Double*	Total
1	55	17	72
2	66	23	89
3	36	10	46
4	67	20	87
5	157	48	205
6	26	15	41
7	15	8	23
8	20	9	29
9	35	18	53
10	78	18	96
11	15	6	21
12	30	8	38
Total	600	200	800
Expected	600	200	800

* "Strong" petalody including some "weak".

However, the total number shown in the table is in perfect agreement with the one expected from a simple ratio, the F_3 data obtained from every cross not being so simple as shown in Table IV.

The table contains those whose percentages of segregation of double flowers in F_2 generation were 25 percent or more, the others being less than this. Considering the circumstances, it is obvious that variable segregation of doubles in the F_3 generation does not always accord with those of F_2.

Some F_2 flowers, which were recorded as doubles and were expected to breed true to doubleness, almost always threw out single flowers in F_3, while we noticed some other single F_2 plants that

TABLE IV.

F_3 data of cross, single × "strong" double.

Cross number	Character of F_2	Number of pedigrees	Single	Double	Total	% of Doubles
1	Single	4	139	—	139	0.0
		4	61	33	94	35.1
	Double	4	4	95	99	96.0
2	Single	11	311	—	311	0.0
		13	233	62	295	21.0
	Double	3	—	35	35	100.0
3	Single	2	56	—	56	0.0
		5	101	63	164	38.4
	Double	2	—	42	42	100.0
4	Single	18	464	—	464	0.0
		1	3	15	18	
		25	411	132	543	24.3
	Double	3	5	68	73	93.2
5	Single	6	115	—	115	0.0
		1	10	43	52	
		13	237	61	298	20.5
	Double	8	23	254	277	91.7
6	Single	4	89	—	89	0.0
		7	84	23	107	21.5
	Double	5	6	63	69	91.3
7	Single	6	190	—	190	0.0
		7	107	38	145	26.2
	Double	4	12	100	112	89.3
8	Single	1	27	—	27	0.0
		2	21	6	27	22.2
9	Single	2	61	—	61	0.0
		4	61	19	80	23.8
	Double	8	11	121	132	97.7
10	Single	22	364	—	364	0.0
		17	301	111	412	26.9
	Double	3	7	41	48	85.4
11	Single	6	127	—	127	0.0
		7	131	35	166	21.1
	Double	2	—	53	53	100.0
12	Single	2	32	—	32	0.0
		3	63	16	79	20.3
	Double	1	2	20	22	90.9

segregated more than 75 percent of doubles.

From these highly confused facts we draw the following conclusion: Manifestation of doubleness has remarkable variability due to environmental conditions, and the double flowers often failed to manifest their character, hence recorded sometimes as singles.

Besides these "strong" doubles, there are some strains of "weak" petalody. When we choose such a type of double for crossing with the single, the double F_2 segregates have similarly "weak" type in the majority of cases, and their ratio is somewhat lower than required by theory, which probably is due to the doubles failing in their proper manifestations. Especially in the double flowers of "weak" petalody, they often fail to manifest the doubleness late in the season. The F_2 data of such a type of doubling are given in Table V.

TABLE V.

F_2 data of cross, single × "weak" double.

Cross number	Single	Double	Total	% of Doubles
1	68	13	81	16.0
2	14	3	17	17.7
3	33	3	36	8.3
4	77	6	83	7.2
5	36	7	43	16.3
Total	228	32	260	12.3

The F_3 data obtained from four crosses are shown in Table VI.

TABLE VI.

F_3 data of crosses, single × "weak" double.

Cross number	Character of F_2	Number of pedigrees	Single	Double	Total	% of Doubles
1	Single	12	207	—	207	0.0
		11	255	52	307	16.9
	Double	2	20	7	27	25.9
3	Single	5	52	—	52	0.0
		2	8	22	30	73.3
		3	47	13	60	21.7
	Double	1	11	11	22	50.0
4	Single	5	54	—	54	0.0
		3	50	7	57	12.3
	Double	1	37	15	52	28.0
5	Single	4	46	—	46	0.0
		1	12	31	43	72.1
		1	41	8	49	16.3
	Double	1	9	4	13	30.8

In these matings, the segregations of double flowers are generally very low in proportion. Segregated double flowers do not usually breed true to type in their next generation; and as we see from the more extreme instances shown in Table VII, the segregating proportions between double and single flowers are reversed.

TABLE VII.

A summary of data of abnormal segregations derived from some crosses, using "weak" petaloid strains.

Cross	F_1	Segregation in F_2	Number of pedigrees	Segregation in F_3 Single	Double	Total	% of Double
Single × Double	Single 2	Single 13	7	88	—	88	0.0
			2	52	3	55	5.5
		Double 26	2	—	22	22	100.0
			6	51	15	66	22.7
Double × Double	Double 1	Single 7	4	131	17	148	11.5
		Double 15	5	99	26	125	20.8

In Tables VI and VII we see several unexpected results as before. That is, notwithstanding that the F_2 plants were chosen at random to test the F_3 generation, in F_3 there were more pedigrees of pure-breeding singles than those of the segregating ones, and the double flowers sometimes were far from breeding true to type. They segregate the singles to a much greater extent than 50 percent.

As mentioned already, the doubleness of balsam is complicated, but still we must assume a gene p_t for the petalody of the flower, bearing in mind the following facts:

1. In the experiment on *Matthiola incana*, SAUNDERS (1911) showed that the environmental factors are powerful enough to influence the manifestation of doubleness. Parallel instances have been furnished by many other investigators with various plants, and balsam is also a good example. With this in view, it is not unreasonable that the true-breeding single-flowered pedigrees exceeded in number compared with the segregating ones, as shown in Table VI.

2. In their experiments with doubleness in *Papaver*, MIYAKE and IMAI (1927) proved at least two recessive genes and a modifier

or modifiers for the low proportion observed in the segregation of double flowers. Variation in the degree of petalody in balsam seems to be due also to the occurrence of a modifier or modifiers that determine the doubleness to a certain degree. With these assumptions it may be interpreted that the segregated doubles were frequently too few in comparison with normal expectations, hence we obtain the unanticipated results shown in Table VII.

3. Camellia Flower.

On selfing, camellia flowers bred true to type, and the manifestation was more or less influenced by environmental circumstances. The strong peloric camellia flower, however, always breed true to its type.

Self-fertilization of the double F_1, which was obtained by crossing the double with the camellia, threw out 41 doubles and 12 camellias, exhibiting a monogenic segregation. Camellia, therefore, is simple recessive. The F_3 trial, which was made with 5 doubles and 3 camellias, produced the results shown in Table VIII.

TABLE VIII.

F_3 data of cross, double × camellia.

Character of F_2	Number of pedigrees	Double	Camellia	Total
Double	2	25	—	25
	3	31	10	41
Camellia	3	—	98	68

On crossing camellia with single, the F_1 obtained always bore single flowers, followed by a dihybrid segregation in F_2, as shown in Table IX.

TABLE IX.

F_2 data of cross, single × camellia.

Cross number	Single	Double	Camellia	Total
1	18	4	6	28
2	63	6	10	79
3	54	3	14	71
4	25	4	4	33
Total	*160*	*17*	*34*	*211*
Expected	118.69	39.56	52.75	211

Such dihybrid segregation as above indicates the occurrence of a camellia gene c_a, besides the petalody gene p_t, which leads us to presume the parental constitution as being $P_t\ C_a$ for singles and $p_t\ c_a$ for camellias. From the double heterozygous F_1 we should expect an F_2 as follows:

$1\,P_tP_tC_aC_a + 2\,P_tp_tC_aC_a + 2\,P_tP_tC_ac_a + 4\,P_tp_tC_ac_a$ . . . . . 9 Single flowers

$1\,p_tp_tC_aC_a + 2\,p_tp_tC_ac_a$ . . . . 3 Double flowers

$1\,P_tP_tc_ac_a + 2\,P_tp_tc_ac_a + 1\,p_tp_tc_ac_a$ . . . . 4 Camellia flowers

There was some marked deviation in their F_3 segregation, as shown in Table X, but it may be supposed as being due to the indefinite manifestation of doubleness. It will be seen, therefore, that our trials with F_3 fully satisfied expectations.

TABLE X.

F_3 data of cross, single × camellia.

Cross number	Character of F_2	Number of pedigrees	Single	Double	Camellia	Total
1	Single	4	174	—	—	174
		7	245	—	58	303
		4	204	58	—	262
		11	154	42	59	255
	Double	4	—	68	—	68
		6	—	219	61	280
	Camellia	2	—	—	125	125
2	Single	2	105	—	—	105
		3	55	—	17	72
		4	66	15	—	81
		6	100	23	54	177
	Double	2	—	26	—	26
		4	—	97	27	124
	Camellia	6	—	—	85	85
3	Single	4	175	—	—	175
		7	213	—	62	275
		5	182	59	—	241
		20	454	118	145	717
	Double	3	—	29	—	97
		7	—	128	57	185
	Camellia	3	—	—	174	174
4	Single	2	50	—	—	50
		5	102	—	30	132
		5	80	24	—	104
		5	154	46	56	256
	Double	3	—	82	23	105
	Camellia	4	—	—	102	102

4. Relation Between Flower Types.

My original double and camellia flowers all belonged to the winged type, and on crossing them with the normal singles, I obtained newly combined forms in the hybrid progeny. For example, cross No. 60, $W_g P_t \times w_g p_t$, gave an F_1, bearing single flowers, while its F_2 was composed of 9 singles, 2 doubles, 5 winged singles, and 1 winged double, showing roughly a dihybrid segregation, though the number observed was very meagre. In another cross No. 42, $w_g p_t c_a \times W_g P_t C_a$, I obtained an F_2 as shown in Table XI.

TABLE XI.

F_2 data of cross 42, winged camellia × single.

	Single	Double	Camellia	Winged	Winged double	Winged camellia	Total
Observed	49	4	8	16	2	2	81
Expected	34.17	11.39	15.19	11.39	3.80	5.06	81

Although the deviation here is remarkable, we have at any rate a trihybrid segregation with respect to the genes for the flower type. The F_3 experimental results obtained with 53 F_2 plants are shown in Table XII.

TABLE XII.

F_3 data of cross 42.

Character of F_2	Number of pedigrees	Single	Double	Camellia	Winged	Winged double	Winged camellia	Total
Single	2	27	—	—	—	—	—	27
	2	56	—	13	—	—	—	69
	2	45	24	—	—	—	—	69
	6	91	—	—	23	—	—	114
	3	68	17	25	—	—	—	110
	3	45	—	16	16	—	3	80
	2	51	15	—	12	3	—	81
	10	117	31	32	38	8	19	245
Double	1	—	10	4	—	—	—	14
	1	—	40	—	15	—	—	55
	4	—	59	11	—	14	4	88
Camellia	2	—	—	37	—	—	—	37
	3	—	—	79	—	—	19	98
Winged	2	—	—	—	23	6	—	29
	3	—	—	—	23	—	14	37
	4	—	—	—	97	33	42	172
Winged double	1	—	—	—	—	11	2	13
Winged camellia	1	—	—	—	—	—	15	15

5. Discussion of Flower Types.

HAGIWARA (1926) studied the hereditary behavior of flower types including single, common double, and camellia. His common doubles may be identified with my winged single. Since the wild species of this genus, such as *Impatiens Textori* MIG., *I. Noli-tangere* L. etc., bear single flowers with incompletely developed wings, the non-winged form may be considered to be the prototype of balsam. From this point of view, it may be correct to call this type the normal. On crossing the camellia with his so-called common double, HAGIWARA obtained an F_2, consisting of common double and camellia flowers in a 3:1 ratio. I, however, obtained an F_2 composed of single, double, and camellia flowers almost in a 9:3:4 ratio from a similar crossing. The difference in the results seems to be due not to difference in the parental genotype, but to a different standard of classification, in which HAGIWARA seems to have counted winged single segregates together with double flowers. This doubt is permissible from the fact that he reported an F_2 segregating in 9 single and 7 double flowers (by his terminology) in the cross, common double × single. On my identification, this crossing actually would be winged double × single, so that its segregation of F_2 should take place in 9 singles, 3 winged singles, 3 doubles, and 1 winged double. He probably recorded the latter three types together in one group as double flowers.

Flower Colors.

The flower color of balsam can be grouped into two classes, red-stemmed and green-stemmed, the latter including seedlings with faintly colored hypocotyls, though the color fades apparently into pure green on the stem. The two groups contain the following flower varieties:

Red-stemmed group		Green-stemmed group	
Term	Color*	Term	Color*
Magenta	"Tyrian Rose"	Dilute purple	"Rose-Purple"
Purple	"Rhodamine Purple"	Very dilute purple	"Pale Vinaceous-Lilac"
		Salmon	"Begonia Rose"
Red	"Spectrum Red"	Dilute red	"Eosin Pink"
Pink	"Geranium Pink"	Very dilute red	"Hermosa Pink"
Pink	"La France Pink"	Dilute pink	"Shell Pink"

* See RIDGWAY's Color Standard and Nomenclature (1912).

All the pink, dilute purple, dilute red and dilute pink tabulated in the foregoing include several other shades as well.

Besides these, we cannot neglect the white flower, the stem of which is pure green.

I. Behavior of Monochromatic Flowers.

A. Results of crossing between red stems.

1. red *v.* pink.

The F_1 flowers of this crossing were red, and in F_2, segregation took place in a monohybrid fashion as shown in Table XIII.

Table XIII.

F_2 data of cross, red × pink.

Cross number	Red	Pink	Total
1	46	21	67
2	18	7	25
3	46	28	74
4	44	15	59
5	13	5	18
6	121	31	152
7	73	19	92
8	47	24	71
Total	408	150	558
Expected	418.5	139.5	558

The result indicates monogenic difference between red (Pl. XII, Fig. 3) and pink flowers (Pl. XII, Fig. 8), and we shall express the recessive allelomorph by p. The F_3 data of these crosses were obtained as shown in Table XIV.

Table XIV.

F_3 data of cross, red × pink.

Cross number	Character of F_2	Number of pedigrees	Red	Pink	Total
1	Red	3	414	—	414
		9	710	192	902
	Pink	10	—	458	458
3	Red	3	98	—	98
		14	439	151	590
	Pink	8	—	511	511
4	Red	3	64	—	64
		6	102	34	136
	Pink	7	—	230	230

In Table XIII, cross 6 was a mating of single red flower × camellia pink flower, and crosses 1, 7, and 8 those of double red flower × camellia pink flower. The data with reference to the segregation of these respective types are given in Table XV for the former and in Table XVI for the latter.

TABLE XV.

Restudy of F_2 data of cross 6.

	Single red	Camellia red	Single pink	Camellia pink	Total
Observed	94	27	24	7	152
Expected	85.5	28.5	28.5	9.5	152

Thus p and c_a were found to be independent of each other.

TABLE XVI.

Restudy of F_2 data of crosses 1, 7 and 8.

Cross number	Single red	Double red	Camellia red	Single pink	Double pink	Camellia pink	Total
1	31	6	9	12	4	3	65
7	45	15	13	11	2	6	92
8	32	13	12	9	5	10	81
Total	108	34	34	32	11	19	238
Expected	100.5	33.5	44.6	33.5	11.2	14.8	238

Since peloric flowers of the camellia type can not be distinguished by mere appearance from the ordinary double type, in Table XVI the simple camellia (c_a) and double camellia (p_t c_a) had to be counted together. From Table XVI, therefore, we see that there are no linkage relations among p, p_t, and c_a.

The F_2 data of Table XVII are from another cross, winged pink flower × normal red flower.

TABLE XVII.

F_2 data showing the relation between p and w_g.

	Normal red	Winged red	Normal pink	Winged pink	Total
Observed	163	54	48	14	279
Expected	156.9	52.3	52.3	17.5	279

From the foregoing data it will be seen that p and w_g act independently of each other, there being no special relationship between them.

2. PINK *v.* PURPLE.

From the purple-flowered F_1, I obtained F_2 plants segregating purple and pink flowers, as will be seen in Table XVIII.

TABLE XVIII.

F_2 data of cross, pink × purple.

Cross number	*Purple*	*Pink*	*Total*
1	60	23	83
2	33	10	43
3	30	13	43
4	89	33	122
5	101	41	142
Total	313	120	433
Expected	324.8	108.2	433

The difference between purple (Pl. XII, Fig. 2) and pink flowers is due to a gene, which may be designated by r. The F_3 data of such crosses are shown in Table XIX.

TABLE XIX.

F_3 data of cross, pink × purple.

Cross number	Character of F_2	Number of pedigrees	Purple	Pink	Total
1	Purple	3	38	—	38
		4	38	10	48
	Pink	3	—	31	31
2	Purple	2	10	—	10
		3	22	7	29
	Pink	5	—	36	36

Crosses 2 and 5 were hybrids of a single pink flower with a double purple flower, and cross 3 of a single purple flower × double pink flower. Segregation data for the color and type of flower in these crosses proved the independent transmission of r and p_t, as shown in Table XX.

TABLE XX.

Restudy of F_2 data of crosses 2, 3 and 5.

Cross number	Single purple	Single pink	Double purple	Double pink	Total
2	22	8	10	2	42
3	19	7	6	2	34
5	74	31	27	10	142
Total	151	46	43	14	218
Expected	122.6	40.9	40.9	13.6	218

3. RED *v.* PURPLE.

The F_1 plants bore magenta flowers (Pl. XII, Fig. 1), differing from both their parental characteristics in their flower color, and gave dihybrid segregation in F_2, as will be seen in Table XXI.

TABLE XXI.

F_2 data of cross, red × purple.

Cross number	Magenta	Purple	Red	Pink	Total
1	20	4	7	2	33
2	15	4	4	2	25
3	47	11	14	5	77
Total	82	19	25	9	135
Expected	75.9	25.4	25.4	8.4	135

As the parents of this crossing differ by one gene from the pink flower and have different allelomorphs, their genetic constitution is *Pr* and *pR* for red and purple flowers, respectively. Since each parent brings its own dominant gene into the crossing, we should obtain a double dominant F_1, which blooms as a magenta flower.

From these results we learn that the magenta flower is the result of cooperative products of two dominant genes. From such a crossing we obtain an F_2 resulting in dihybrid segregation into magenta, purple, red, and pink flowers. A trial with F_3 obtained from two crosses gave the result shown in Table XXII.

TABLE XXII.

F_3 data of cross, red × purple.

Cross number	Character of F_2	Number of pedigrees	Magenta	Purple	Red	Pink	Total
1	Magenta	1	25	—	—	—	25
		6	99	—	33	—	132
		5	116	28	39	10	192
	Purple	1	—	12	—	—	12
	Red	2	—	—	151	—	151
		4	—	—	155	46	201
	Pink	2	—	—	—	28	28
2	Magenta	1	32	—	12	—	44
		2	45	9	23	11	88
	Purple	1	—	15	—	—	15
	Red	1	—	—	16	—	16
		1	—	—	30	8	38
	Pink	1	—	—	—	42	42

Since cross 2 was the mating of single red × camellia purple, its F_2 segregation of flower type in addition to the flower color is as shown in Table XXIII.

TABLE XXIII.

Restudy of F_2 data of cross 2, showing segregation of color and type of flower.

	Single magenta	Single red	Single purple	Single pink	Camellia magenta	Camellia red	Camellia purple	Camellia pink	Total
Observed	37	12	9	4	10	2	2	1	77
Expected	32.5	10.8	10.8	3.6	10.8	3.6	3.6	1.2	77

Although the number examined may be insufficient, it is certain that there is no linkage between p, r, and c_a.

4. RED *v.* MAGENTA.

Theoretically, this mating is $Pr \times PR$, the expectation being an F_1 having magenta flowers and an F_2 causing monohybrid segregation into magenta and red flowers. This was the actual case in my experiment, as shown in Tables XXIV and XXV.

TABLE XXIV.

F_2 data of cross, red × magenta.

Cross number	Magenta	Red	Total
1	42	9	51
2	38	9	47
3	39	13	52
Total	119	31	150
Expected	112.5	37.5	150

TABLE XXV.

F_3 data of cross 2.

Character of F_2	Number of pedigrees	Magenta	Red	Total
Magenta	7	150	—	150
	11	131	38	169
Red	3	—	81	81

Cross 3 segregated flower type in addition to flower color, throwing out 28 single magenta, 9 single red, 11 double magenta, and 3 double red flowers. The result seems to be an additional proof *that the segregation of r is quite independent of p_t as mentioned* above.

5. PINK *v.* MAGENTA.

Since the parents of this cross are a doubly recessive and a doubly dominant, we should expect magenta-flowered F_1, giving rise to dihybrid segregation in the next generation of four types, magenta, purple, red, and pink flowers. The F_2 and F_3 data thus obtained proved this to be true, as indicated in Tables XXVI and XXVII, though the numbers observed were insufficient.

TABLE XXVI.

F_2 data of cross, pink × magenta.

	Magenta	Purple	Red	Pink	Total
Observed	11	5	2	0	18
Expected	10.13	3.38	3.38	1.23	18

TABLE XXVII.

F_3 data of cross, pink × magenta.

Character of F_2	Number of pedigrees	Magenta	Purple	Red	Pink	Total
	1	46	—	—	—	46
Magenta	3	49	—	15	—	64
	2	55	13	27	6	101
Purple	2	—	41	—	15	56
Red	1	—	—	23	—	23
	1	—	—	12	3	15

6. PURPLE *v.* MAGENTA.

The F_1 plants of this crossing bore magenta flowers, and monohybrid segregation took place in F_2, as shown in Table XXVIII.

TABLE XXVIII.

F_2 data of cross. purple × magenta.

Cross number	Magenta	Purple	Total
1	57	11	68
2	41	11	52
Total	98	22	120
Expected	90	30	120

Cross 2 actually segregated the flower type in addition to the flower color, as shown in Table XXIX.

TABLE XXIX.

Restudy of the F_2 data of cross 2, showing segregation of color and type of flower.

	Magenta	Winged magenta	Purple	Winged purple	Total
Observed	31	10	8	3	52
Expected	29.3	9.7	9.7	3.3	52

This may be additional data in proof of the independent segregation of p and w_g, mentioned above.

B. Results of crossing red stems with green stems.

The foregoing data concern crossings of red-stemmed specimens. We shall now deal with results bearing on the green-stemmed varieties.

1. Red *v.* dilute red.

The F_1 plants of this mating bore red flowers, and in the next generation, segregation of flower color occurred in a monohybrid scheme, as will be seen in Table XXX.

Table XXX.

F_2 data of cross, red × dilute red.

Cross number	Red	Dilute red	Total
1	23	6	29
2	27	8	35
Total	50	14	64
Expected	48	16	64

The qualitative difference in the shades of the red and dilute red flowers (Pl. XII, Figs. 6 and 7) is due to the difference of one single gene for the stem color. The allelomorphs which also effect the intensity of the flower color, will be designated as *S* and *s* (stem-green).

2. Pink *v.* dilute red.

As was proved with the previous crossing, the dilute red flower is a red flower with green stem, in other words, genotypically *rrPPss*, and as the pink-flowered partner carries a *rrppSS*-constitution, it will give rise to red-flowered F_1 in this crossing by bringing together the genes *P* and *S*. Since the crossing thus involves two diverse genes, a segregation ratio of 9 : 3 : 3 : 1 is expected in F_2, in which the double recessives should be pink flowers with green stems, their flowers presumably being dilute pink (Pl. XII, Fig. 4) owing to the influence of the *ss*-genes. Table XXXI contains the F_2 data obtained by selfing such red-flowered F_1.

TABLE XXXI.

F_2 data of cross, pink × dilute red.

Cross number	Red	Pink	Dilute red	Dilute pink	Total
1	46	14	9	3	72
2	45	24	18	2	89
3	47	14	9	4	74
4	60	25	19	6	110
Total	198	77	55	15	345
Expected	194.1	64.7	64.7	21.5	345

The results obtained with the F_3 test fulfilled what was theoretically expected as shown in Table XXXII.

TABLE XXXII.

F_3 data of cross, pink × dilute red.

Character of F_2	Genetic composition	Number of pedigrees	Red	Pink	Dilute red	Dilute pink	Total
Red	*PPSS*	1	141	—	—	—	141
	PpSS	8	243	83	—	—	326
	PPSs	3	73	—	30	—	103
	PpSs	4	121	40	46	15	222
Pink	*ppSS*	5	—	190	—	—	190
	ppSs	7	—	131	—	39	170
Dilute red	*PPss*	1	—	—	26	—	26
	Ppss	6	—	—	110	41	151
Dilute pink	*ppss*	2	—	—	—	41	41

In the F_2 generations of crosses 3 and 4, the flower type as well as the flower color was segregated, the actual numbers being given in Table XXXIII.

TABLE XXXIII.

Restudy of the F_2 data of crosses 3 and 4, showing segregation of color and type of flower.

Cross number	Red	Double red	Pink	Double pink	Dilute red	Double dilute red	Very dilute red	Double very dilute red	Total
3	36	11	11	3	7	2	3	1	74
4	45	15	16	9	14	5	5	1	110
Total	81	26	27	12	21	7	8	3	184
Expected	77.7	25.8	25.8	8.8	25.8	8 8	8.8	3.6	184

From these results we may regard *p*, *s*, and p_t as being independent of one another.

3. MAGENTA *v*. DILUTE RED.

As the mating is *RRPPSS* × *rrPPss*, F_1 should bloom magenta flowers, dihybrid segregation being expected in its F_2. This actually proved to be the case, as shown by the F_2 and F_3 data in Tables XXXIV and XXXV respectively.

TABLE XXXIV.

F_2 data of cross, dilute red × magenta.

Cross number	Magenta	Red	Dilute purple	Dilute red	Total
1	30	14	4	3	51
2	10	3	5	2	20
3	7	3	4	2	16
Total	47	20	13	7	87
Expected	48.94	16.31	16.31	5.44	87

TABLE XXXV.

F_3 data of cross I.

Character of F_2	Genetic composition	Number of pedigrees	Magenta	Red	Dilute purple	Dilute red	Total
Magenta	*RRPPSS*	2	35	—	—	—	35
	RrPPSS	2	58	18	—	—	76
	RRPPSs	3	115	—	42	—	157
	RrPPSs	6	104	43	33	18	198
Red	*rrPPSS*	1	—	79	—	—	79
	rrPPSs	1	—	32	—	8	40
Dilute purple	*RRPPss*	1	—	—	14	—	14
Dilute red	*rrPPss*	3	—	—	—	57	57

4. RED *v*. DILUTE PURPLE.

According to the experience with the foregoing matings, the genetic constitution of the dilute purple (Pl. XII, Fig. 5) is believed

to be *RRPPss*, so that the F_1 flowers of this crossing were expected to bloom in magenta color and to result in dihybrid segregation with respect to the genes *r* and *s* in their F_2. Two crosses being made by using dilute purple flowers of different pedigrees, one gave the expected result, but the other showed quite a different segregation. The F_2 data of the former are given in Table XXXVI, while those showing the unexpected result will be found in Table XXXVII. Table XXXVIII gives the F_3 data of the latter.

TABLE XXXVI.

F_2 data of cross, dilute purple × red.

	Magenta	Red	Dilute purple	Dilute red	Total
Observed	58	17	16	5	96
Expected	54	18	18	6	96

TABLE XXXVII.

F_2 data of cross of another dilute purple *Rps* with red.

	Magenta	Purple	Red	Pink	Dilute purple	Dilute red	Dilute pink	Total
Observed	24	8	7	2	13	2	0	56
Expected	23.63	7.88	7.88	2.63	10.50	2.63	0.88	56

TABLE XXXVIII.

F_3 data of cross, *Rps* × *rPS*.

Character of F_2	Genetic composition	Number of pedigrees	Magenta	Red	Purple	Pink	Dilute red	Dilute purple	Dilute pink	Total
	RrPPSS	1	43	13	—	—	—	—	—	56
	RRPpSS	1	20	—	8	—	—	—	—	28
Magenta	*RrPpSS*	1	18	5	8	3	—	—	—	34
	RRPpSs	1	24	—	9	—	—	11	—	44
	RrPpSs	5	115	20	15	8	4	27	2	191
Purple	*RrppSS*	1	--	—	35	11	—	—	—	46
Red	*rrPpSS*	2	—	10	—	3	—	—	—	13
Dilute purple	*RRppss*	1	—	—	—	—	—	37	—	37
	RrPPss	2	—	—	—	—	8	29	—	37
Dilute red	*rrPPss*	1	—	—	—	—	24	—	—	24
	rrPpss	1	—	—	—	—	18	—	4	22

As the segregations in Tables XXXVII and XXXVIII occurred in a trihybrid scheme, not dihybrid as in Table XXXVI, the parental dilute purple flowers of these matings should be regarded as being *RRppss*, but not *RRPPss*. This assumption would imply that the distinction in their phenotypes of magenta and purple flowers in the green-stemmed variety would be difficult. If this be the case, the dilute purple flowers should increase in number upon summing up the segregates of the two types. In Tables XXXVII and XXXVIII are so many dilute purples that the assumption may be taken as valid. The expected numbers in Table XXXVII were calculated on the basis of 27 : 9 : 9 : 3 : 12 : 3 : 1, a somewhat modified dihybrid ratio.

C. Results of crossing with white flower.

Since I think that with the foregoing descriptions the genetic relations of flower-colors have been made fairly clear, I shall now proceed to discuss the genotype of the white flower.

1. Dilute red *v*. white.

The F_1 bore dilute red flowers, and in their F_2, the results shown in Table XXXIX were obtained.

Table XXXIX.

F_2 data of cross, white × dilute red.

Cross number	Dilute red	Dilute pink	White	Total
1	40	26	12	78
2	7	1	1	9
Total	47	27	13	87
Expected	48.94	16.31	21.75	87

The actual segregation approaches the ratio of 9 dilute red, 4 dilute pink, and 3 white (Pl. XII, Fig. 13), but this seems to be a deviation of 9 : 3 : 4. I, therefore, presumed gene *w* to be the cause of segregation of white flowers. The genetic constitution of the white parent is *wwrrPPss*, since its partner, dilute red, is regarded as carrying a *WWrrPPss*-constitution. Trials with the F_3 of this

cross proved this presumption to be correct, as shown in Table XL.

TABLE XL.

F_3 data of cross, white × dilute red.

Character of F_2	Number of pedigrees	Dilute red	Dilute pink	White	Total
	1	22	—	—	22
Dilute red	2	44	15	—	59
	5	66	24	34	124
Dilute pink	4	—	114	—	114
	10	—	213	105	318
White	14	—	—	306	306

Some of the segregates recorded as whites in the F_2 and F_3 generations were actually colored very dilutely and were probably of *wwrrPPss* or *wwrrPpss* constitution. But it was impossible to identify them among the pure whites on account of the faintness of their colors, for which reason I have been obliged to include them in the white.

The results given above show that there is no linkage between the genes *p* and *w*.

2. PINK *v.* WHITE.

The F_1 flowers were pink, and in their F_2, the segregation occurred in a monohybrid scheme as shown in Table XLI.

TABLE XLI.

F_2 data of cross, white × pink.

Cross number	Pink	White	Total
1	13	6	19
2	41	14	55
Total	54	20	74
Expected	55.5	18.5	74

Since the white-flowered parents carry the *ss*-constitution with respect to the stem color, the F_2 of the present crossings may be

expected to contain some dilute pink and very dilute pink flowers as single recessives. As shown in the preceding table, the actual results, however, disprove this. It seems to indicate the occurrence of a high degree of coupling between *w* and *s*, which if it is really the case, the present crossing, *WWrrppSS* × *wwrrppss*, then shows the reason why it gave in F_2 a monohybrid instead of dihybrid segregation. Tests made of F_3 with cross 2 gave results as shown in Table XLII.

TABLE XLII.

F_3 data of cross, white × pink.

Character of F_2	Number of pedigrees	Pink	Dilute pink	White	Total
Pink	6	97	—	—	97
	12	154	2	45	201
White	6	—	—	94	94

Summing up the data of dihybrid segregation from the F_2 and F_3 generations (it being admissible to include all the white-throwing data of pink pedigrees in the calculation, owing to the very strong linkage), we obtained 208 pink, 2 dilute pink, and 65 white. From these figures the linkage value for *w* and *s* is estimated to be 1.4 percent.

3. PURPLE *v.* WHITE.

Two crosses were made by using white flowers of different pedigrees. Both F_1 hybrids bore purple flowers and segregated F_2 as shown in Table XLIII.

TABLE XLIII.

F_2 data of cross, white × purple.

Cross number	Purple	Pink	Dilute purple	Very dilute purple	White	Total
1	54	14	10	—	3	81
Expected	45.5	15.2	15.2	—	5.1	81
2	34	9	—	13	13	69
Expected	26.1	9.7	—	12.9	17.3	69

The F_3 data relating to the segregation from cross 1 are shown

in Table XLIV. Those for cross 2 will be dealt with later.

TABLE XLIV.

F_3 data of cross 1.

Character of F_2	Number of pedigrees	Purple	Pink	Dilute purple	White	Total
Purple	3	72	18	—	—	90
	9	163	—	52	—	215
	5	98	30	39	13	180
Pink	3	—	69	—	—	69
	3	—	51	—	18	69
Dilute purple	2	—	—	26	—	26
White	2	—	—	—	40	40

Since this crossing may be regarded as being *wwrrppss* × *WW-RRppSS*, F_1 is expected to be triply heterozygous, but, actually, dihybrid segregation should occur in F_2, owing to the nearly complete linkage of *w* and *s*.

From these results it is evident that there is no linkage between *r* and *w*.

4. MAGENTA *v*. WHITE.

As this mating was *WWRRPPSS* × *wwrrppss*, the F_1 plants produced magenta flowers, segregating in the F_2 generation as shown in Table XLV.

TABLE XLV.

F_2 data of cross, magenta × white.

	Magenta	Purple	Red	Pink	Very dilute	White	Total
Observed	39	9	12	4	17	2	83
Expected	35.02	11.67	11.67	3.89	19.45	1.30	83

The three classes, *wwRRPPss*, *wwrrPPss* and *wwRRppss*, which, theoretically ought to be segregated, are practically indistinguishable, the one from the other, owing to the very dilute coloration, so

that they were gathered under the class "very dilute" in the table.

As to the phenomenon that in the F_2 generation of the mating a very dilute flower took the place of a dilute flower, I shall refer to it in a later section.

D. Results of crossing with very dilute flower.

In some crosses shown above covering the white flower, there segregated very dilute flowers, the behavior of which is considerd in this section.

1. WHITE *v.* PURPLE.

From cross 2 of white × purple, described in Table XLIII, the F_3 generation was tested with results as shown in Table XLVI.

TABLE XLVI.

F_3 data of cross 2 of white × purple.

Character of F_2	Number of pedigrees	Purple	Pink	Very dilute purple	White	Total
Purple	3	57	—	—	—	57
	4	60	18	—	—	78
	4	58	—	15	—	73
	3	48	17	16	8	89
Pink	2	—	23	—	—	23
	1	—	16	6	—	22
Very dilute purple	7	—	—	161	—	161
	10	—	—	177	44	221
White	5	—	—	—	86	86

2. MAGENTA *v.* WHITE.

With respect to this mating, the manner of segregation has already been mentioned in connection with the F_2 data, wherein we learned that very dilute segregates took the place of dilute segregates. This condition is also noticed in the F_3 generation as shown in Table XLVII.

TABLE XLVII.

F_3 data of cross, magenta × white.

	Magenta	Purple	Red	Pink	Very dilute	White	Total
Observed	39	12	9	4	17	2	83
Expected	35.02	11.67	11.67	3.89	19.45	1.30	83

In addition to these results, other experiments showed the following conditions, recognizing the segregation of gene *d* for the color intensity.

1. The very dilute color of the flower is due to the effect of a diluting gene *d*, the common flowers carrying its dominant mate.

2. Close or almost complete linkage takes place between *d* and *w*.

Under these circumstances, the white parents of two crosses of white × purple and magenta × white, both of which have been referred to already, is found to have a *ddwwrrppss*- constitution.

3. PURPLE *v.* VERY DILUTE PINK.

A cross between very dilute pink (Pl. XII, Fig. 9) and purple gave F_1 plants bearing purple flowers, segregation in F_2 occurring as shown in Table XLVIII.

TABLE XLVIII.

F_2 data of cross, very dilute pink × purple.

	Purple	Pink	Very dilute purple	Very dilute pink	Total
Observed	52	15	23	6	96
Expected	54	18	18	6	96

From this result, the mating was recognized undoubtedly as being *ddWWrrppss* × *DDWWRRppSS* in constitution, which, needless to say, is reasonable in view of the almost complete linkage between *d* and *s*.

4. RED *v.* VERY DILUTE PURPLE.

In this mating, the F_1 bore magenta flowers, and observations

of F_2 showed the complicated segregation as given in Table XLIX.

TABLE XLIX.

F_2 data of cross, very dilute purple × red.

	Magenta	Purple	Red	Pink	Very dilute	Total
Observed	16	6	12	5	12	51
Expected	21.52	7.17	7.17	2.39	12.75	51

Since the hybridization then is considered to be *DDWWrrPPSS* × *ddWWRRppss* genetically, the F_1 would be quadruply heterozygous, and in F_2 sixteen types should theoretically be expected to segregate. Actually, however, owing to the almost complete linkage between *d* and *s*, we ought practically to obtain triple segregation as follows:

Genetic composition	Ratio	Phenotype		Ratio
DRPS	27	Magenta		27
DRpS	9	Purple		9
DrPs	9	Red		9
DrpS	3	Pink		3
dRPs	9	Very dilute purple	Very dilute	16
dRps	3	Very dilute purple		
drPs	3	Very dilute red		
drps	1	Very dilute pink		

The expected numbers in Table XLIX were calculated from the foregoing ratio. Although the number examined may not be enough, it is quite certain that the observed result agrees well with expectation.

E. INHERITANCE OF SPUR COLOR.

For the purpose of studying the inheritance of spur color in balsam, a cross was made between a pure stock, having white flowers with colored spurs (Pl. XII, Fig. 12) and another pure strain, having very dilute red flowers (Pl. XII, Fig. 11) with white spurs (Pl. XII, Fig. 10). The result was dilutely red-flowered F_1 having colored spurs. On selfing three F_1 plants thus raised, I obtained F_2, segregating abnormally, as shown in Table L.

The F_1 plants of this mating bore somewhat more intense colored flowers than the dilute red (Pl. XII, Fig. 7).

TABLE L.

F_2 data of cross, white with colored spur × very dilute red with white spur.

	Dilute red		Very dilute red		White		
	With colored spur	With white spur	With colored spur	With white spur	With colored spur	With white spur	Total
Observed	109	54	29	20	45	17	274
Expected	102.9	51.9	33.4	17.4	51.1	17.5	274

A white parent of this mating had a wR-constitution obtained from a pedigree culture. If then the gene for spur-white be designated by s_p (spur-white), this cross must be $wwRRS_pS_p \times WWrrs_ps_p$, and the F_1 would be $WwRrS_ps_p$. And if there be no special relationship among the genes, the F_2 would be expected to segregate trihybridly, dilute red with colored spur, dilute red with white spur, very dilute red with colored spur, very dilute red with white spur, white with colored spur, and white with white spur, but the actual data showed no better agreement with expectations.

From these results we may point out the following facts:

1. S_p manifests its coloring effect on the spur even when the flower has ww. Consequently, in the F_2 generation of this cross, the white-spured segregates may reasonably be 7/64, that is, 3/64 of wrS_p, 3/64 of wRs_p, and 1/64 of wrs_p.

2. Since r and s_p are linked to each other very closely, the ratio, 27 : 9 : 9 : 3 : 7, mentioned above, will be modified again. Although the number examined may not be enough, the recombination frequency was calculated to be 7.0 percent for r and s_p. The expected ratio given in Table L was drawn on such a basis.

II. BEHAVIOR OF STRIPED FLOWERS.

A. FORMS OF STRIPED FLOWERS.

The characteristics of the six variegated strains with which this study is concerned, are as follows:

STRAIN I. Fine red-striped (Pl. XII, Fig. 17). The ground color of the flower varies from almost white to dilute red. Re-

markable variegation in red and pink appears on these ground colors.

STRAIN II. Coarse red-striped (Pl. XII, Fig. 18). Although the ground color and stripe color are the same as those of Strain I, variegation is not very marked.

STRAIN III. Fine pink-striped. The flower is a very dilute color with pink and lighter stripes. The stripes are considerable in quantity.

STRAIN IV. Coarse pink-striped (Pl. XII, Fig. 19). This strain resembles the flowers of Strain III, but shows the stripes to a less marked degree.

STRAIN V. Fine purple-striped (Pl. XII, Fig. 16). Purple and dilute purple stripes are distributed to a somewhat marked degree on the ground-colors of very dilute purple or dilute purple.

STRAIN VI. Fine magenta-striped. Magenta and purple variegations occur on the ground color, which varies from almost white to dilute purple (Pl. XII, Figs. 14 and 21). In this strain is involved a type having only magenta variegation (Pl. XII, Fig. 15), the ground color of the latter appearing to vary from very dilute magenta to dilute magenta.

B. THE PROGENIES OF STRIPED FLOWERS.

STRAIN I. On selfing eight striped plants, 6 red stems were obtained out of 307 seedlings, the proportion of the red being 1.95 percent. It will presently be made clear that these red individuals are mutants as in the other cases of striped plants. These red stems came to bloom self-red flowers, the color of which quite agrees with the intense color of the stripes on the flower of Strain I. However, the green stems, as a matter of fact, are striped stems that generally grew up to bear striped flowers of the parental type, although a part of them flowered in the ground color. Examination of the green-stemmed offsprings of these striped plants in 61 specimens, showed 51 bearing striped and 10 ground-colored flowers, the mixing proportion of the latter being 16.39 percent.

One plant bearing ground-colored flowers thus derived, when selfed, gave 59 plants that bred true to type. One self-red mutant, however, segregated into 15 self-red, 6 striped, and 2 ground-colored flowers in its offspring.

STRAIN II. Only a very few red stems appeared in this case; namely, 5 reds in 654 offsprings of twenty two striped plants, or 0.76 percent. According to observation of 234 green stems, 20 of them, or 8.55 percent of the total, flowered in ground color, the rest being striped. Six plants, bearing flowers in ground-color thus derived were selfed, when the 100 plants obtained invariably bore flowers of the same color as their parents. The red stems that appeared as mutants developed self-red flowers. In three reds that were selfed for the purpose of raising offspring, I found them segregating into 60 red and 13 green stems in all, thus exhibiting approximately data of simple segregation. I examined the flower color of the offspring of one of these three pedigrees and in 8 plants found 7 self-red and 1 ground-colored flowers. The red mutant, therefore, was incidentally a heterozygote for ground color. Five red segregates thus derived gave two true-breeding famillies for the self-red flower and three segregating ones. The total offsprings of the former were 75 in number, while the latter families comprised 112 red and 24 ground-colored flowers in 136 plants out of the total, showing nearly a monohybrid ratio.

STRAIN III. Of 52 offsprings obtained by selfing one fine pink-striped plant, 7, or 13.46 percent, were red-stemmed pink flowers, 8, or 17.78 percent, ground-colored flowers, and the remainder, 37 specimens, striped flowers.

STRAIN IV. Five red-stemmed seedlings were obtained out of 210 offsprings of the three striped plants of Strain IV, their mixing proportion being 2.38 percent. Following the usual rule, these red-stems grew up to bear pink flowers. Of these green stems, those for which records were taken of their flower color numbered 121, containing 111 striped and 10 ground-colored flowers; the proportion of the latter being 9.10 percent.

STRAIN V. Of 44 offsprings, obtained by selfing two striped plants belonging to this strain, 2, or 4.27 percent, of red stems were obtained. Notwithstanding that I failed to have one of them bloom, the other bloomed into a self-purple flower. By selfing the remaining 42 plants I found that out of them 37 were striped and 5 almost white, the throwing-out ratio of the latter being 11.36 percent. On selfing purple flower, I obtained S_2 (the second generation showing segregation) plants, consisting of 33 red stems and 12 green stems out of 45, showing that segregation had occurred

in a monohybrid ratio.

Another striped specimen belonging to this strain threw out 39 plants in S_1, all of which bore striped flower of the type.

STRAIN VI. Thirty-five, or 13.31 percent, of red stems were obtained from 363 offsprings of five striped plants. The green stems, which were allowed to grow in the field, were 144 in number, and contained 6 ground-colored flowers among the striped individuals, the proportion of the former being 4.35 percent. By selfing four ground-colored flowers, I obtained 77 plants that bred true to type. The intense color of the stripes on flowers of this form is magenta. The red-stemmed mutant that appeared in the progeny of the striped flowers all bloomed into magenta flowers. The progeny of two such magenta-flowered plants consisted of 38 red and 13 green stems, showing a simple segregation.

C. ABNORMAL PROGENIES OF STRIPED FLOWERS.

1. APPEARANCE OF MONOCHROMATIC FLOWERS.

Our six forms of striped flowers habitually produced two kinds of self-colored flowers, intense and ground-colored, in their offspring, as was shown in the previous section, though the mixing frequency was very variable. Table LI shows the summarized frequency of two kinds of self-colored flowers from each strain of striped flower.

TABLE LI.

The proportion of mutants that appeared in various striped strains.

Striped strain	% of Red stems	% of Ground-colored flowers
I	1.95	16.39
II	0.76	8.55
III	13.46	17.78
IV	2.38	9.10
V	4.27	11.36
VI	13.31	4.35

Generally speaking, the frequency in the red stems is lower than that in ground-colored flowers, but the case was quite reversed in Strain VI.

A number of investigators have made experiments with striped plants of various species and published the results of their painstaking researches, of which we may mention *Antirrhinum* (DE VRIES 1905, BAUR 1924), *Mirabilis* (CORRENS 1905, 1910, BAUR 1908, MARRYAT 1909, KANNA 1933), *Zea* (EMERSON 1914, 1917, EYSTER 1924, HAYES 1917), *Celosia* (TERASAWA 1921, KANNA 1930, KOJIMA 1930, KIHARA 1932) *Pharbitis* (IMAI 1925, 1927, 1931), etc. In all these cases, monochromatic mutants occur in the progeny of the variegated strains, the same feature having been repeatedly observed in my balsam. If we designate the gene for the striped condition by s^v (variegated), the self-colored state is due to the effect of its dominant allelomorph, since variegation acts as a recessive to self-coloration. As was experimentally proved, the self-colored mutants were heterozygous to the striped flower, so that their constitution is supposed to be Ss^v. The origin of some of these mutants may lie in the gametogenesis, in which a few gametes happened to carry the gene S, having been transformed from its recessive mate. We should then also expect homozygous ones in the red-stemmed mutants by the union of two S-gametes, although the chances of obtaining such plants may be very rare. As to the reason for the red-stemmed mutants blooming in the most intense color of the variegated strains, it is due to the expression of the genotype of the strain or form, in other words, the difference in striped strain and its red-stemmed mutants lies in the Ss^v-allelomorphs, the other constituents of the flower color being the same. That is, the common constitutents in the respective strains for the flower color are *rrPP* in Strains I and II, *RRpp* in Strain V, *rrpp* in Strains III and IV, and *RRPP* in Strain VI, are experimentally proved.

In addition to the red-stemmed mutants, the striped strains of balsam throw out some ground-colored flowers in their offspring by self-fertilization. CORRENS (1910) and PUNNETT (1922) obtained similar flowers with striped or patched strains of *Mirabilis* and *Lathyrus*. In my balsam, the ground-colored flowers thus thrown out from striped specimens bred true to type as above mentioned. And as will be referred to later, three forms, self-colored, variegated, and ground-colored, constitute multiple allelomorphs. If therefore we represent the ground-colored by s, then S, s^v, and s, are three members of a series of multiple allelomorphs, and the origin of the ground-colored plants must have been due to s^v chang-

ing to *s*. The mutability of this s^r is frequently seen not only seminally but also somatically. All the striped condition are nothing more than what has originated from the mutability of s^r.

2. APPEARANCE OF THE INTENSE GROUND-COLORED FLOWER.

On selfing the striped strain, we have, though very infrequently, one more abnormal-flowered type, striped individuals blooming flowers with the most intense ground-colors, such as dilute red in Strains I and II, dilute pink in Strains III and IV, dilute purple in Strain V, and dilute magenta (Pl. XII, Fig. 21) in Strain VI.

Our trials with the next generation derived by selfing uncommon striped plants showed that intense grouud-colored flowers are not of simple cases of fluctuation. The actual results are as follows:

TABLE LII.

S_2 offspring of intense ground-colored S_1 from strains with dilute ground color.

Strain	Number of pedigrees	Self-colored	Striped with intense ground-color	Striped with dilute ground-color	Intense ground-colored	Dilute ground-colored	Total
I	2	2	24	16	3	0	45
V	1	0	13	3	1	1	18
VI	1	0	8	3	0	1	12

These results serve to confirm the view of monohybrid segregation, although the data were not sufficient in number. We shall designate the gene for the dilute condition of the ground color by *e* (ecru), hence the parental stock must be in *ee*-condition. The intense ground-colored plants, which were habitually thrown out from the striped strains together with those of dilute ground color, were the mutants originated by $ee \rightarrow Ee$.

D. BUD-VARIATION AND ITS GENETIC BEHAVIOR.

1. MONOCHROMATIC BUD-VARIATION.

The occurrence of monochromatic flowers is a common phenomenon in some striped strains. It is so in balsam, but the be-

havior is somewhat more complicated. A general description will now be given in regard to the nature of the various forms of my pedigree strains.

STRAIN I. Fine red-striped. In this strain, three forms of bud-variation are recognized: (1) red flowers or branches occurring on green stems with colored pubescence, (2) red flowers or branches occurring on red stems with colored hair, and (3) flowers of intense pink occurring on red stems with white hair (Pl. XII, Fig. 22).

The last-named flowers, however, are intense pink variegated with red stripes. Of three types (1) occurs often, while (2) and (3) are rare. It is worthy of note that the color of the stem or hair differs with the color of the flower. The reason for such a difference in these three forms is probably the fundamental diversity in their periclinal constitution.

STRAIN II. Coarse red-striped. Red and intense pink bud sports are found, although the latter is much less frequent. This behavior is almost similar to that of the fine red-striped strain.

STRAIN IV. Coarse pink-striped. Pink flowers frequently occur with green or red stem. Owing to the low frequency of the stripes, plants bearing apparently stripeless flowers are sometimes produced, though they can be identified with the type by their flecked stems, which is a general characteristic of the striped strains.

STRAIN V. Fine purple-striped. In this strain, we frequently find monochromatic purple flowers on green stem with red hair and rarely dilute purple flowers on red stem with white pubescence.

STRAIN VI. Fine magenta-striped. Monochromatic magenta flowers on green stem with red pubescence are often noticed and also two other forms of magenta flowers borne on red stem with red hair, besides, although rarely, dilute magenta flowers with magenta stripes on red stem with white hair (Pl. XII, Fig. 20). In addition to these three forms, an unusual form of bud-variation seen in this strain was a striped one that specially interested me by its subdued ground color, the stem color being green and the hair white.

Summing up then, the types of monochromatic bud-sports in balsam may be classified into four groups: (A) self-colored type on green stem, with red hair; red in Strains I and II, pink in Strains III and IV, purple in Strain V, and magenta in Strain VI, (B) self-colored type on red stem, with red hair, which has several types

corresponded with those cited in (A), (C) striped type on red stem with white hair; intense pink in Strains I and II, dilute purple in Strain V, and dilute magenta in Strain VI, and (D) subdued type on green stem, with white hair; striped with subdued ground color in Strain VI.

By selfing the various bud-sports that appeared on the striped plants from each strain, we obtained the following results (Table LIII).

TABLE LIII.

Offsprings of four types of monochromatic bud-variations of striped strains.

Strain	Type of monochromatic bud-variation	Red stem	Green stem	Total	Segregation percentage of red stems
	A	11	74	85	12.9
I	*B	18	13	31	58.1
	*C	39	31	70	55.7
	A	2	21	23	8.7
II	Striped	2	45	47	4.3
	*C	3	5	8	37.5
IV	A	0	28	23	0.0
V	*C	13	4	17	76.5
	A	15	97	112	13.4
	B	25	7	32	78.0
VI	C	30	11	41	73.2
	*C	8	6	14	57.1
	D	0	28	28	0.0

In this table, results marked * were obtained by open pollination.

Type A in Strains I, II, IV, and VI, and type D in Strain VI were the same genotypes as the respective striped flowers in regard to the sub-epidermal tissues, therefore they gave the striped offspring prevalently. HAGIWARA (1926), who also studied the striped forms, recognized that monochromatic bud-variation is not inherited. Before drawing conclusions, however, it is desirable to know the hereditary behavior of other forms of bud-variation.

In Strain VI, types B and C segregated in a 3:1 ratio, demonstrating that the recessive variegation gene s^v has mutated to its domi-

nant self-color allelomorph *S*. And in types B and C in Strain I, as well as in type C in Strains II and VI, the data approach a ratio of 1 : 1, while Strain V showed segregation in simple Mendelian F_2 ratio. Generally balsam is hardly self-pollinated in the natural state, hence the occurrence of such rogues in open-pollinated pedigrees may not be rare. Owing to this reason, we may say that the data, excepting those of Strain V, are the results of natural crossings.

TABLE LIV.

Summary of the various monochromatic sports, with their characters shown.

Strain	Type of mono-chromatic bud-variation	Color of flower	Color of stem	Color of hair	Mutated tissue	Heredi-tary nature	Frequency of appear-ance
I	A	red	green	red	ecto-histogen	non-heritable	frequent
II	A	red	green	red			
IV	A	pink	green	red			
VI	A	magenta	green	red			
I	C	intense pink with stripes	red	white	meso-histogen	heritable	rare
II	C	intense pink with stripes	red	white			
V	C	dilute purple with stripes	red	white			
VI	C	dilute magenta with stripes	red	white			
I	B	red	red	red	at least ecto- and meso-histogen	heritable	quite rare
VI	B	magenta	red	red			
VI	D	subdued magenta with stripes	green	white	endo-histogen	non-heritable	extremely rare

Therefore, the type B occurred through the gene mutation $s^r \rightarrow S$ in its meso-histogen. Various bud-sports above mentioned have arisen by somatic mutation. When the ecto-histogen, or the first layer, is composed of mutated cells, the flower is self-colored and the hair growing on the fruit is red, the stem remaining green (type A), but when the mutated cells are concerned with the meso-histogen, or the second layer, the flower is somewhat dilute colored

with intense stripes, the stem being red and the hair remaining white (type C). When however mutation has occurred in both the first and second layers, the flower, stem and hair are all red (Type B). Type D observed in Strain VI seems to show that the endo-histogen, or the third layer, consists of mutated cells, although no evidence of it could be obtained. These conditions were summarized as shown in Table LIV.

2. INTENSE GROUND-COLORED BUD-VARIATION WITH STRIPES.

In every strain intense ground-colored bloomed at times on ordinary dilute ground-colored plants. Such flowers, in their features, agree with those mentioned in section C–2.

Type C of the preceding section is also intense ground-colored in appearance, the ground color however being more intense than that just mentioned. The type is produced by the mutation $s^r \rightarrow S$.

Since the ground color of the former bud-sport is not hereditary, it must be distinguished from the latter, so that in order to study such bud-variations, the sports were selfed and obtained the result as is shown in Table LV.

TABLE LV.

Offsprings of intense ground-colored sports that appeared in the striped strains with dilute ground color.

Strain	Number of branches tested	Red stem	Striped		Ground-colored		Total
			Intense ground color	Dilute ground color	Intense	Dilute	
I	8	2	4	41	4	2	53
VI	9	5	3	40	0	2	50
VI	1	2	13	6	1	0	22

From this result it will be seen that most such bud-sports, excepting the one in Strain VI, are not of heritable variation. But it is certain that in one branch from Strain VI, segregation was of a monohybrid scheme, though the number examined may not have been enough. The conclusion, therefore, is that the mutation $e \rightarrow E$ habitually occurred also in somatogenesis, often in the first layer but seldom in the second.

3. BUD-VARIATION WITH RESPECT TO THE QUANTITY OF STRIPES.

Since the self-colored region of the striped corolla is believed to be composed of mutant tissues, the somatic mutation which occurred early in the development of the flower, results in broad stripes, while in the case of mutation occurring late in ontogeny, we have instead fine flecks, the frequency of the former being high and that of the latter low. The degree of variegation on the corolla corresponds to the frequency of the mutation.

In my investigations on the striped strain, I classified the degree into two classes, "coarse" and "fine", the former containing much fewer flecks between the stripes than the latter and because the former is a much coarser flower. The conclusion from these observations is that the "fine" variegation is manifested in the case of high frequency of the somatic mutation and the "coarse" one in that of low frequency.

Since the "fine" striped plant has at times "coarse" flowers or coarse branches as a bud-sport, I bred the progenies from three such branches and obtained 37 plants, all of which had the same original degree. From this it may be probable that the mutation from "fine" to "coarse" affected the ecto-histogen alone. Studying this specimen, I find that with respect to the characteristics just mentioned, the similar things were met with *Mirabilis* that I also studied (KANNA, 1930).

E. INHERITANCE OF THE STRIPED FLOWERS.

In this section, I shall discuss certain results furnishing evidence of the genetic nature of the striped strains in their crossings.

RED × STRAIN I. From the F_1 plants bearing red flowers I obtained F_2 segregated as follows:

TABLE LVI.

F_2 data of cross, red × Strain I.

	Red	Strain I	Total
Observed	59	20	79
Expected	59.25	19.75	79

The results of the F_3 examination are given in Table LVII, which is the segregation of a monohybrid fashion.

TABLE LVII.

F_3 data of cross, red × Strain I.

Character of F_2	Number of pedigrees	Red	Strain I	Ground-colored	Total
	6	97	—	—	97
Red	10	157	56	3	216
	1	65	—	28	93
Strain I	13	10	313	4	327
	2	5	47	13	65

The results indicate that the mating was $DWrPS \times DWrPs^v$; indicating that the s^v habitually varied to self-red (S) and the ground color (s).

VERY DILUTE RED × STRAIN I. On selfing the F_1 plants bearing striped flower of Strain I, I obtained F_2, which segregated 5 red flowers, 63 striped flowers of Strain I, and 24 ground-colored flowers, demonstrating the simple ratio of parental forms. The cross may thus be considered to be $DWrPs \times DWrPs^v$.

VERY DILUTE RED × RED. The F_1 plants obtained by crossing a very dilute red flower (ground-colored) with a red flower, bore red flowers. Three such F_1 plants were selfed, when the F_2 segregated 133 red-flowered and 14 very dilute red-flowered, confirming the mating to be $DWrPs \times DWrPS$.

In the three crossings above mentioned, the red flower, the striped flower of Strain I, and the ground-colored flower, acted as monohybrids in their crossing with one another. As to the other striped strains, cases analogous to this will be mentioned in the following paragraphs.

VERY DILUTE RED × STRAIN III. The F_1 plant bearing striped flowers of Strain III produced F_2, segregating 13 striped flowers and 7 ground-colored flowers.

VERY DILUTE PURPLE × STRAIN V. On selfing the striped F_1 flowers, I obtained F_2, 62 being striped and 26 very dilute purple-flowered.

STRAIN VI × MAGENTA. The magenta-flowered F_1 gave the

following data showing that the genotype of Strain VI corresponds to the magenta flower having a gene for variegation.

TABLE LVIII.

F_2 data of cross, Strain VI × magenta.

	Magenta	Strain VI.	Total
Observed	84	25	109
Expected	81.75	27.25	109

In the F_3 generation of this cross the result was as shown in Table LIX.

TABLE LIX.

F_3 data of cross, Strain VI × magenta.

Character of F_2	Number of pedigrees	Magenta	Strain VI	Ground-colored	Total
Magenta	7	129	—	—	129
	7	242	74	7	323
Striped	7	—	113	2	115

The next section concerns the attempt to find the relation between the different striped strains, and to obtain a clearer view of the genetic nature.

STRAIN VI × RED. The F_2 segregation obtained by selfing the magenta-flowered F_1 hybrids is as follows (Table LX).

TABLE LX.

F_2 data of cross, Strain VI × red.

	Magenta	Red	Striped		Total
			Strain VI	Strain I	
Observed	14	7	12	2	35
Expected	19.7	6.6	6.6	2.1	35

The difference in genotype between Strains I and VI is monogenic for r.

PURPLE × STRAIN VI. On selfing the magenta-flowered F_1 raised

by this mating, I obtained F_2, which segregated 16 magenta flowers, 10 purple flowers and 10 striped flowers of Strain VI.

The segregations were very meagre, appearing as if repulsion was taking place between the segregated genes. The doubly recessive form in this case is a striped flower with purple variegation.

STRAIN I × STRAIN VI. A plant of Strain I, when crossed with the pollen of two different plants of Strain VI, gave different results owing to difference in the male parents. In the F_1 generation one cross gave 4 plants, all of which flowered in Strain VI, while the other yielded 6 plants out of which 4 were of Strain I and 2 of Strain VI. The F_2 results obtained by selfing these F_1 are shown in Table LXI for the former and Table LXII for the latter. Although a greater number of individual might have been desirable in experiment, the genetic constitution of the parents of these crosses are no doubt $rrPPs^vs^v$ × $RRPPs^vs^v$ for the one cross and $rrPPs^vs^v$ × $RrPps^vs$ for the other.

TABLE LXI.

F_2 data of cross, Strain I × Strain VI.

	Strain VI	Strain I	Reddish magenta	Total
Observed	20	6	1	27
Expected	20.3	6.7	(x)	27

TABLE LXII.

F_2 data of another cross, Strain I × Strain VI.

Phenotype of F_1	Genotype of F_1	Number of pedigrees	Strain VI	Strain I	Strain V	Strain IV	Red	Ground-colored	Total
Strain VI	$RrPPs^vs$	1	5	3	—	—	—	4	—
	$RrPps^vs$	1	5	4	4	1	—	7	—
Strain I	$rrPPs^vs$	3	—	34	—	—	1	11	—
	$rrPps^vs^v$	1	—	22	—	8	—	3	—
	$rrPps^vs$	4	—	42	—	11	—	13	—

STRAIN III × STRAIN VI. All the F_1 plants that bore flowers of strain VI were selfed and the resulting F_2 is shown as follows:

Table LXIII.

F_2 data of cross, Strain III × Strain VI.

	Strain VI	Strain V	Strain I	Strain III	Red	Purple	Ground-colored	Total
Observed	32	7	15	5	5	2	6	72
Expected	40.5	13.5	13.5	4.5	(x)	(x)	(x)	72

From this result, the genetic constitution of the parents used in this cross seems to be $rrpps^ls^l \times RRPPs^vs^v$.

2. On the intensity of ground color.

Strain I with intense ground color × Strain III with dilute ground color. By crossing a striped flower with the intense ground color of Strain I with a striped flower with the dilute ground color of Strain III, I obtained F_1, bearing striped flowers with the intense ground color of Strain I. On selfing two such F_1 plants, the F_2 indicated that segregation of the intensity of ground color occurs in a monohybrid ratio as shown in Table LXIV.

Table LXIV.

F_2 data of cross, Strain I with intense ground color × Strain III with dilute ground color.

Cross	Red	Intense ground color			Dilute ground color			Total
		Strain I	Strain III	Ground-colored	Strain I	Strain III	Ground-colored	
1	0	208	11	0	13	58	0	290
2	1	48	11	11	10	15	5	100
Total	1	256	22	11	23	73	5	390
			289			101		

Dilute purple × Strain VI with dilute ground color. The dilute purple used in this cross was of the most intense ground color that could be seen in Strain VI. In the hybridization of such a flower with Strain VI having a dilute ground color, the F_1 plants were Strain VI with intense ground color. In the subsequent generation, I obtained results as shown in Table LXV.

TABLE LXV.

F_2 data of cross, dilute purple × Strain VI with dilute ground color.

	Intense ground color				Dilute ground color				Total
	Strain VI	Strain V	Magenta self-c.	Purple self-c.	Strain VI	Strain V	Magenta self-c.	Purple self-c.	
Observed	98	27	39	37	56	8	2	1	268
	201				67				

The mating is undoubtedly $DWRpsE \times DWRPs^{v}e$ in their genetic constitution.

In Tables LXIV (cross 1) and LXV, none of expected self-magenta and self-purple were segregated in the F_2 generation. If this will be repeatedly proven the fact may indicate that certain mechanisms are at work in gametogenisis for the absence of mutability $s^{v} \rightarrow S$.

DILUTE PURPLE × STRAIN V WITH DILUTE GROUND COLOR. The F_1 plant obtained from this crossing flowered in Strain V with intense ground color. I selfed these four F_1 plants with segregations of the intense and dilute in a simple ratio as shown in Table LXVI.

TABLE LXVI.

F_2 data of cross, dilute purple × Strain V with dilute ground color.

	Purple	Intense ground color		Dilute ground color		Total
		Strain V	Self-colored	Strain V	Self-colored	
Observed	4	49	26	23	1	103
		75		24		

The result shows that the mating was $DWRpsE \times DWRps^{v}e$.

3. THE RELATION BETWEEN e AND p, s, OR w_g.

Several of the results mentioned above furnished clearer evidences for the behavior of the allelomorphs E, e.

We shall now consider the relation between e and some other genes. Since from the figures of Table LXIV, the mating of which was $PE \times pe$, the coupling distribution is recognizable, the frequency of recombination has been calculated from the figures as 14.2 percent. In Table LXVI, which is the F_2 data of $sE \times s^{v}e$, the distribution of the figures shows that repulsion took place. The per-

centage of recombination from these data is 16.7. In the F_2 data of *psE* × *Ps'e* (Table LXV), the observed numbers seem to satisfy the recombination values for *p-e* and *e-s* thus calculated.

The F_2 result of cross 1 indicated in Table LXIV segregated also with respect to the winged condition and the intense ground color, the data being shown in Table LXVII.

TABLE LXVII.

Restudy of the F_2 data of cross 1 from Table LXIV, showing segregation of w_g and *e*.

	Normal, intense ground-colored	Normal, dilute ground-colored	Winged, intense ground-colored	Winged, dilute ground-colored	Total
Observed	157	54	53	15	279
Expected	156.9	52.3	52.3	17.5	279

The result shows that the segregating ratio is in simple dihybrid fashion, indicating that *e* is transmitted independently to w_g.

4. THE QUANTITY OF STRIPES.

On crossing a striped flower of Strain I with that of Strain II, the resultant F_1 hybrids were red-striped with an intermediate quantity of stripes. Since the F_2 segregation occurred with a wide range as to their quantity, the distinction of the one form from the others was very difficult, but I have been able to divide them into three classes, fine, intermediate, and coarse in the ratio shown in Table LXVIII.

TABLE LXVIII.

F_2 data of cross, Strain I × Strain II.

	Red	Fine striped	Intermediate striped	Coarse striped	Ground-colored	Total
Observed	12	65	142	48	11	278
Expected	(*x*)	69.5	139.0	69.5	(*x*)	278

As the result shows monohybrid segregation of the three forms in the ratio of nearly 1:2:1, I call the gene for reducing variegation *v-r* (variegated-reduced), its dominant allelomorph *V-r* resulting in a fine striped.

White Blotches.

Some strains have white blotches (Pl. XII, Fig. 2) on their flowers, their occurrence, however, being very uncertain and irregular, even in the same individual. RASMUSON (1920), who used a white-blotched strain in his experiments, stated that the white blotches behave as a simple dominant to the normal condition. Contrary to it, however, in my crossing, the trait acted as a recessive, although its segregating aspect was not simple. For studying its genetic nature, two types, "light" for the few white blotches and "heavy" for the many, were used. The F_1 plants obtained by cross *light* × normal were normal. Cross, light × heavy, however, produced heavily blotched F_1. On selfing such F_1 plants, I obtained F_2, segregating as shown in Table LXIX.

TABLE LXIX.

F_2 data showing segregation of white blotches.

Cross	Character of F_1	F_2 result			
		Normal	Light	Total	Normal: white blotches
(1) Normal *v.* light	normal	11	2	13	5: 1
(2) 〃	〃	138	3	141	48: 1
(3) 〃	〃	72	8	80	9: 1
(4) 〃	〃	30	3	33	10: 1
Total	〃	251	16	267	1: 1
(5) Light *v.* heavy	heavy	50	70	120	1: 1

Although the segregating proportions of light in the different crosses showed considerable variation, the ratio calculated from the total data was very nearly 15: 1, a modified dihybrid ratio due to the occurrence of duplicate genes, which might, however, be an accidental coincidence. On the other hand, in the F_2 of cross light × heavy, about fifty percent of normal were produced, against the expectation that all the F_2 plants would be white blotched. To clear up these unexpected features, the F_3 was studied from crosses 3 and 5, the resulting data being given in Tables LXX and LXXI.

TABLE LXX.

F_3 data of cross, light × normal.

Character of F_2	Normal	White blotches	Total	Normal: white blotches
Normal	30	4	34	11.8
"	27	3	30	10.0
"	40	6	46	13.0
"	40	6	46	13.0
"	84	2	86	2.0
"	46	1	47	2.1
"	55	11	66	16.7
White blotches	1	6	7	85.7
	5	13	18	72.2

TABLE LXXI.

F_3 data of cross, light × heavy.

Character of F_2	Normal	White blotches	Total	Normal: white blotches
Normal	25	30	55	54.5
"	26	46	72	63.9
"	28	14	42	33.3
"	14	21	35	60.0
"	0	22	22	100.0
"	0	34	34	100.0
"	1	12	13	92.3

We shall designate the gene for the recessive white blotches by the symbol, *w–b*. As already stated, the manifestation of *w–b* is so irregular and uncertain that we fear that some of the plants might fail to make full expressions throughout their growth. Under such circumstances, it will be seen that the seemingly obscure results collected in the three foregoing tables are now clarified.

Deficient Seedlings.

Quite unexpectedly I found some deficient seedlings with normal sisters in a pedigree. The data contained about one-fourth of deficients, as is shown in Table LXXII.

TABLE LXXII.

F_2 data showing segregation of deficient.

Cross number	Normal	Deficient	Total
1	38	11	49
2	86	19	105
Total	124	30	154
Expected	115.5	38.5	154

Of these crosses, I examined F_3 of cross 1, the data of which are summarized in Table LXXIII.

TABLE LXXIII.

F_3 data of cross 1, showing segregation of deficient.

	Normal	Deficient	Total
Observed	86	19	105
Expected	78.8	26.2	105

On the deficient plant body, the cotyledons, leaves, and stems, which, through their abnormal forms appear at first sight to be lacking, are in reality whitish morbid substitutes, hence deformed. This extraordinary feature, however, becomes generally inconspicuous in later plant growth. Owing to stunted growth in the seedling stage, these plants may easily die off. At first glance the trait appears to be due to some disease, but it is transmitted as a simple recessive. Similar features were detected also by IMAI (1925) in the Japanese morning glory, *Pharbitis Nil*.

If we designate the gene for the deficient character by d_f, the origin of the deficiency then lies in a gamete produced by the grandparent; namely, mutation, $D_f \rightarrow d_f$, takes place in one gamete, which, uniting with a normal gamete, should produce a heterozygous parent plant.

Albino Seedlings.

A number of occurrences or segregation of albinotic seedlings have been reported. The albinism is transmitted as recessive to normal green. In 1927, a spontaneous segregation of albinism in F_2 pedigrees of certain crosses of balsam arrested my attention,

the data collected being presented in Table LXXIV.

TABLE LXXIV.

F_2 data showing segregation of albinotic seedlings.

Cross number	Number of pedigrees	Green	Albino	Total	Percent of albinos
	5	788	——	788	0.0
1	10	543	154	697	22.1
	Expected	522.8	174.2	697	25.0
	9	792	——	192	0.0
2	13	830	261	7091	23.9
	Expected	818.3	272.8	1091	25.0
	2	22	——	22	0.0
3	3	238	71	309	22.9
	Expected	231.8	77.2	309	25.0

Although albinotic seedlings contain more or less chlorophyll, owing to its amount being insufficient to support their existence for long, the seedlings dye off wihout putting out leaves about two weeks after germination. The deficit of albinotic segregates (23.18%) is mainly due to their low viability. The segregation is in accordance with simple ratio where there is monogenic difference between green and albino. The gene for albinism will here be expressed by a_l. Since three F_2 pedigrees were derived from the common pistilate parent, the plant should furnish some egg-cells carrying mutated genes a_l when cross-fertilized.

Fasciation.

Fasciation is rarely found in balsam. I observed two types of fasciation, the one hereditary and the other not so.

Hereditary fasciation appeared sporadically with a white-flowered F_3 plant of a cross. Although in some cases, fasciation showed its characteristic by assuming dichotomic or trichotomic branching in early plant growth, in general a flattening occurs at the apices of the stems at a late stage of growth, the stems exhibiting extraordinary monstrosity later. Such hereditary fasciation occurred only

once during these 11 years of observation. In non-hereditary fasciation, on the contrary, flattening of the stems occurs early in plant growth, the degree of flattening being less conspicuous than the former. I have observed eight cases in which non-hereditary fasciation appeared sporadically. Three fasciated plants when selfed gave 21 offspring, none of which were fasciated.

Hereditary fasciation crossed with finely purple striped stock with normal stems yielded three normal F_1. The F_2 data obtained are shown in Table LXXV.

TABLE LXXV.

F_2 data of cross, fasciated white × normal purple striped.

	Striped		Dilute and white		Total
	Normal	Fasciated	Normal	Fasciated	
Observed	88	25	35	11	159
Expected	89.4	29.9	29.9	9.8	159

If we represent the gene for fasciation by f, the cross is expressed by $wPsf \times Wps^vF$. From the data shown in Table LXXIII, f may be independent of s in their segregation.

Conclusion.

The genes treated in the present paper are as follows:

w_g . . . . for the development of wing petals, resulting in a winged form.

pt . . . . for doubleness.

c_a . . . . for camellia type of doubleness.

s' . . . . for anthocyanin variegation.

s. . . . . for back-ground color, constituting a set of multiple allelomorphs with S and s^v, the order of dominancy being S—s^v—s.

p. . . . . in the coexistence of R, p being responsible for purple flower and its dominant P for magenta flower.

r. . . . . results in a red flower in the coexistence of P, and a pink flower in the coexistence of p.

w . . . . for white flower.

d. . . . . for very dilute colored flower.

s_p . . . . for spur color, resulting in a white spur.
e . . . . . for the back-ground color, resulting in a dilute coloration.
$v–r$ . . . for reduction in the degree of variegation.
$w–b$ . . . for white blotching.
d_f . . . . for defective foliage.
a_l . . . . for albinism.
f . . . . . for fasciation.

Of these, linkage relations between 11 genes have been studied, the results being collected in the accompanying table. Thus the *s*

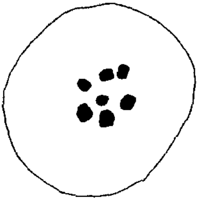
	w_g	pt	c_a	s	r	p	w	d	s_p	e	f
w_g	w_g										
pt	ind.	pt									
c_a	ind.	ind.	c_a								
s	ind.	ind.	ind.	s							
r	ind.	ind.	ind.	ind.	r						
p		ind.	ind.	ind.	ind.	p					
w		ind.	ind.	link.	ind.	ind.	w				
d		ind.	ind.	link.	ind.	ind.	link.	d			
s_p					link.				s_p		
e	ind.				link.					e	
f				ind.							f

linkage group contains three genes, *s*, *w*, and *d*, and the *r* linkage group includes three more genes, *r*, s_p, and *e*, while the other genes were independent in segregation so for as my observations were concerned.

The chromosomes of balsam were counted by KACHIDZE (1925), KANNA (1926) (Text-fig. 1), and MORINAGA and FUKUSHIMA (1931), all reporting 7 in haploid. The linkage tests being incomplete, the linkage groups, however, will not exceed seven in number, although the other genes will be independent of one another.

Variegation is manifested by gene s^v, the degree of variegation being qualified by gene $v–r$. Gene s^v being inconstant, it mutates to its dominant allelomorph *S* and to its recessive *s*. Mutability

differs in the different pedigrees, including an extreme case in which mutants are hardly obtainable. In *Celosia* (TERASAWA 1922) and *Zea* (EMERSON 1914), the self-red mutants had a characteristic of mutating to the variegated form, or in other words, the recurrent mutation is reversible between variegated and self-red. In balsam, however, the self-colored mutants are highly constant as is generally the case.



Text-fig. 1. *Heterotypic* metaphase of pollen mother cell of balsam (×2000).

By somatic change into S, gene s^v results in magenta, red, purple, and pink variegations with coexistence of RP, Pr, pR and pr respectivly. The occurrence of monochromatic mutants in the respective variegated forms is due to mutation from s^v to S or s, the changes probably taking place partly in gametogenesis. According to DEMEREC (1926, 1928), reddish-alpha of *Drosophila virilis* gives only individual mutants and not a single mosaic fly. In this case, the recurrent mutation is only gametic. However, in other general cases, in which mutation occurs vegetatively as well as seminally, it is difficult to decide whether the mutation arises in gametogenesis or in somatogenesis.

Frequently intense monochromatic bud-variations appear in the respective variegated stocks, due to respective somatic mutations that occurred in the early cell-generation in the development of branches or flowers. The color or coloration and the genetic behavior of bud-variation are determined by the position of the mutated histogen in the stem or flower. This fact was suggested by CORRENS (1910) and worked out anatomically and genetically by EMERSON (1922), KOJIMA (1930), IMAI (1931) and KIHARA (1932). IMAI (1934) intends to discuss the general problems in relation to the mechanism of bud-variation on the basis of results obtained in his studies of *Pharbitis*. According to IMAI's terminology, the tri-histogenic plant is composed of ecto-, meso-, and endo-histogens. It is not yet determined that balsam is a tri-histogenic dicotyledons. From the fact that most dicotyledons are tri-histogenic, balsam is presumed to be so in this paper. I have identified two types of bud-variations, one being intense monochromatic flowers,

green stems, and red hair, the other having light flowers with variegation, red stems and white hair; the former due to ecto-histogenic and the latter to meso-histogenic bud-variation. The former therefore gives mostly variegated progeny, while the latter segregates into self-colored and variegated.

The amount of variegation in balsam is affected by a reducer, *v–r*. Studying the variegated *Verbena*, EYSTER (1928) reported that medium is dominant to heavy, which in turn is recessive to light. In balsam, the two types of fine and coarse variegations are transmitted according to intermediate inheritance, namely, the heterozygotes exhibit an intermediate amount of variegation. EMERSON (1922) doubted the occurrence of a modifying gene for mutability in *Mirabilis*, on the ground that the proof presented by CORRENS (1910) was inadequate. Compared with the two types of fine and coarse variegation, the larger stripes are common in both types, but differ considerably in the smaller dots. Gene *v–r*, therefore, *which is active in its manifestation at a late stage of flower de-*velopement, suppresses mutability at this stage. BAUR (1924) pointed out the fact that the coarse type of variegation in *Antirrhinum* produce fine type, and he assumed certain modifiers to account for the variability in the extent of variegation. In balsam, I observed cases of bud-variations that occurred from coarse to fine.

The intensity of the back-ground color is reduced by gene *e*. This gene is variable, changing into its dominant *E* at every stage of ontogeny. Somatic mutation occurs frequently in ecto-histogen, but not to the same extent in meso-histogen.

Summary.

1. The behavior af 3 genes affecting the flower type, and that of 10 genes for flower color, and 3 for the other characters, are described.

2. Two linkage groups are established, including 6 genes. The *s* linkage group contains 3 genes, *s*, *w* and *d*, and the *r* linkage group includes 3 other genes, *r*, s_p and *e*. While most of the other genes were independent in their segregation.

3. The striped flowers habitually produce monochromatic flowers in an intense color as mutation, $s^v \rightarrow S$, in their progeny.

4. The striped strains also throw out some plants bearing

ground-colored flowers, which bred true to type, owing to mutation $s^v \rightarrow s$.

5. S, s^v, and s constitute a set of multiple allelomorphs, the order being S—s^v—s.

6. Four types of bud-variation are frequently observed on the striped specimens. The genetic nature of these types closely relates to the position of the mutated histogen in the stems or flowers.

7. The striped strains change their intensity of ground color owing to mutable gene c.

8. The degree of variegation is affected by a reducer v–r, resulting in two types of fine and coarse variegations. The types are transmitted as intermediate inheritance.

9. Occasionally, bud-variations were observed occurring from coarse to fine variegation.

10. The white blotch acts as a recessive character in inheritance, but its segregating aspect is not simple.

11. Albinism is manifesed by a recessive gene.

12. The appearance of deficient seedlings seems to be due to gene mutation, dominant → recessive.

13. Two types of fasciation were observed, hereditary and non-hereditary.

14. The haploid chromosome number of balsam is seven.

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EXPLANATION OF PLATE XII.

Fig. 1. Winged, weakly petaloid, magenta flower.
Fig. 2. Winged, single, purple flower with white blotches.
Fig. 3. Winged, single, red flower.
Fig. 4. Winged, single, dilute pink flower.
Fig. 5. Winged, weakly petaloid, dilute purple flower.
Fig. 6. Winged, camellia, dilute red flower.
Fig. 7. Winged, camellia, salmon flower.
Fig. 8. Winged, strongly petaloid, pink flower.
Fig. 9. Winged, single, very dilute pink flower.
Fig. 10. White spur.
Fig. 11. Winged, single, nearly white flower with red spur.
Fig. 12. Red spur.
Fig. 13. Winged, single white flower.
Fig. 14. Winged, single flower finely striped with tri-colors.
Fig. 15. Winged, single flower finely striped with magenta.
Fig. 16. Winged, single flower finely striped with purple.
Fig. 17. Normal, strongly petaloid flower finely striped with red.
Fig. 18. Winged, strongly petaloid flower coarsely striped with red.
Fig. 19. Winged, single flower coarsely striped with pink.

Fig. 20. Winged, single, fine magenta-striped chimerical flower (meso-histogenic).

Fig. 21. Winged, camellia, fine tricolor-striped flower with intense ground-color.

Fig. 22. Normal, "strong"-petaloid, red-striped chimerical flower (meso-histogenic).

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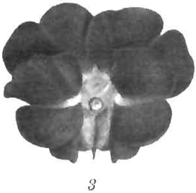

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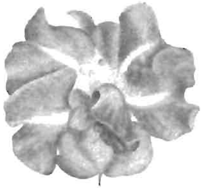

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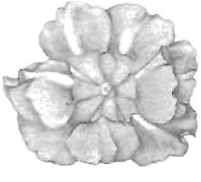

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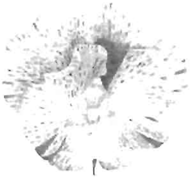
Plate XII.



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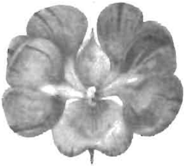

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matogenesis, in others either only in gametogenesis or in both cases. The mutable nature of the genes is of importance in studying the mechanism of bud-variations, or in that of the formation of periclinal chimeras. The purpose of this paper is to describe the behavior of mutable genes in *Pharbitis*, extending the discussion to the general problems above stated.

List of Mutable Genes in *Pharbitis*.

In *Pharbitis Nil* twenty (possibly more) mutable genes, situated in seventeen loci, were investigated, including those unpublished. The following list contains these loci with short remarks.

1. contracted (*ct*): Whole plant body contracted, reverting to normal; most of the contracted strains however are constant (IMAI 1927a, and present paper).

In the former publication (IMAI 1927a), I presented data on the mutability of gene contracted, giving somatic reversion as well as seminal mutants that were heterozygous normals. Further new data proved the lability of the contracted line, two progeny plants

Fig. 1. Sectorial leaf, half normal (left) and half contracted (right). Crumpling of leaf is due to gene crumpled-1.

being the mosaic of contracted and normal. One of the specimens showed a sectorial chimera, partly contracted and partly normal, sometimes bearing mosaic leaves (Fig. 1) and flowers. But the other was contracted, bearing periclinal branches with contracted 'skins' and normal 'cores' (Fig. 2). On account of the coarse texture of the inner mesophyll, the leaves of the chimerical branches

Fig. 2. Periclinal leaf with contracted 'skin' and normal 'core'. *Note crumpling of leaf due to heterogeneous tissues,* but not to gene crumpled-1.

are somewhat crooked and crumpled. The data presented in Table I were obtained through sowing seeds collected from the latter mosaic plant.

TABLE I.

Character of branch	Normal	*Contracted*	Total
Contracted	0	21	21
Periclinal	1	24	25

The results accorded with our expectations, proving the periclinal structure of the branches that had contracted sub-epidermal tissues. The mutable contracted line however was lost before making further studies. BLAKESLEE's dwarf *Portulaca* (1920) is also mutable, reverting to normal.

2. cream (*cr*): Creamish flowers with a few normal-colored stripes, due to recurring somatic mutations: seminal mutants also occur (IMAI 1925a, 1927a).

3. delicate (*dl*): Leaves with sharp-pointed lobes and less protruding shoulders, mesophyll thin, flowers split, fertility low; sometimes mutable, reverting to normal (IMAI 1927a).

4. dotted (*dt*): Dotted flower, reverting to self-colored condition (TERAO and U 1930).

5. duskish (*dk*): Composed of a graded series of multiple allelomorphs. Roughly speaking, they are near-stable-plain (dk^{ns}), unstable-plain (dk^{us}), ordinary-ruled (dk^{or}), highly-ruled (dk^{hr}), and normal. Near-stable-plain and unstable-plain result in plain duskish flowers, sometimes with a few normal-colored spots; ordinary-ruled and highly-ruled produce variegated flowers with different amount of variegation. Near-stable-plain rarely reverts to normal, others transform mutually and to normal (IMAI 1931, and in press c).

6. flecked (*fl*): White flower with normal-colored flecks, frequently reverting to self-colored condition (IMAI 1931, and present paper).

7. lobeless (*ls*): Lobeless leaves, complete sterility, reverting to normal (TERAO and U 1930).

8. miniature-inconstant (mi^i, probably allelomorphic to constant miniature): Organs miniature, flowers split, bloom in small cluster, complete sterility; reverts to normal (TERAO and U 1930).

9. pine-inconstant (pi^i): Cotyledons very small, leaves filiform, flowers split very narrowly, reverting to normal and mutating to constant pine (IMAI 1927a; U 1930).

The *phantastica* form of *Antirrhinum* has also 'nadelartig' leaves, frequently reverting to normal (BAUR 1924, 1926a). Another slender leaf form of this plant, *graminifolia*, seems also to be mutable (SCHIEMANN 1926).

10. pipy (*pp*): Flowers tubular in form, at times reverting to normal (IMAI and KANNA, unpublished data).

11. purple (*pr*): Purple flower, rarely reverting to normal

condition (IMAI, *present paper*).

A few remarks on the behavior of gene purple will now follow. Purple, which is a recessive gene producing a purple flower, results in a red flower in cooperation with gene magenta. Close examination of purple or red flowers reveals at times the occurrence of blue (on purple flowers) or magenta (on red flowers) flecks, rarely forming their mono-chromatic flowers. By selfing six plants that bore purple flowers with some blue stripes, I raised 272 seedlings, 4 of which later bloomed blue flowers and the rest purple, excepting one mosaic. The occurrence of normal variants is 1.5 percent. Two of these normals were examined for their progeny, which consisted of 78 normal and 24 purple flowers. The normal variants are therefore due to mutations from recessive to dominant in their origin. The mosaic plant for blue and purple flowers gave rise to 42 purple plants from purple flowers, whereas 35 blue and 13 purple plants were obtained from blue flowers, showing the occurrence of a vegetative mutation in the mother plant. Reverted blue flowers, when they became homozygous, bred true to type in the offspring. On the basis of these data we arrived at the conclusion that gene purple is of mutable nature, reverting to normal.

12. speckled (*sp*): Speckled flowers, rarely reverting to self-colored (TABUCHI, unpublished data).

13. willow (m^w): Willow leaves, corolla splits into narrow petals, pistilate organ nearly completely sterile, mutating to maple (IMAI 1925b, 1927a) and rarely to normal (TABUCHI, unpublished data).

14. wrinkled (*wr*): Corollas wrinkled, somewhat star-shaped, fertility generally low, rarely reverting to normal (IMAI 1927a).

15. xanthic (*x*, formerly called golden): Yellow cotyledons and leaves; dies after germination without extending leaves; sometimes with green patches due to somatic reversions (IMAI 1930b; TERAO and U 1930).

16. yellow-inconstant (y^i): Yellowish green cotyledons and leaves, frequently with green patches; revert to normal (IMAI 1927b, 1930a, and present paper; MIYAZAWA 1929, 1932).

17. yellowy (*ye*): Young leaves yellowish green and finely mottled with green dots, green mottling extends later, become nearly green leaves, sometimes reverting to normal (IMAI 1930b, and present paper).

The mutable genes so far known in *Pharbitis* act as recessives to the prototypic normal, from which they arose by sporadic mu-

tations in the course of evolution under cultivation. The recurring mutations occur both vegetatively and seminally. In some of my previous papers, I hesitated to regard the anthocyanin flecks in the corollas as results of mutation, but recent experiments cause me to believe that they are so. That is, in such flowers as cream, flecked, purple, and possibly dotted, the anthocyanin flecks are evidently due to recurring somatic mutations that occurred in the late cell-generation of the corollas. In speckled, however, the variegation, general speaking, is a pattern character, sometimes mixed together with a few flecks due to somatic mutations. The duskish variegation seems to depend on plasmic manifestation under the control of certain genes (IMAI, in press c). All mutable genes so far found in *Pharbitis* exhibit both vegetative and seminal mutations. With the exceptions now to be stated, the recurring mutations take place as reversions from the recessives to their dominant prototype. The willow, however, generally mutate to maple, which forms multiple allelomorphs with normal and willow. In this set of allelomorphs, maple behaves as recessive to normal and dominant to willow. Therefore the recurring mutation occurs to the gene of the second rank in the allelomorphic series, but not to the prototype. In the duskish graded allelomorphs, some complicated reversible changes arise, frequently from recessive to dominant and *vice versa*. This is the only case found in *Pharbitis* in which the recurring mutations take place also from dominant to recessive. Of these twenty mutable genes, yellow-inconstant, yellowy, and flecked will be treated further in the following sections.

Two Yellow-inconstant Stocks.

Gene yellow, which results in mono-chromatic yellowish green leaves (known as 'yellow leaves'), is located in the yellow chromosome (IMAI 1933, IMAI and TABUCHI 1933). Yellow is allelomorphic to yellow-inconstant and normal (IMAI 1930a), the former manifesting yellowish green leaves, frequently with green patches and the latter self-green leaves. The order of dominancy is normal—yellow-inconstant—yellow. Of these multiple allelomorphs, yellow-inconstant is mutable, frequently changing to its dominant condition, but never to its recessive state, while the others are highly constant. The origin of yellow-inconstant is old and its history can

be traced back about 120 years (IMAI 1927b). Its strain, which is still being maintained, has been the subject of my investigations. MIYAZAWA (1929, 1932) also studied the same character of this plant, but its origin is different; it was obtained under his observation as a new mutant character in a hybrid progeny. Both forms being mutable, they bear yellow leaves with green patches and show mosaics of yellow and green as well as green mutants in their progeny. The appearance of the green and mosaic plants in the two forms of yellow-inconstant, however, differ greatly in their frequency. With the object of making comparative studies of them, we exchanged seeds, I receiving seeds of the new yellow-inconstant from Professor MIYAZAWA, to whom I wish to express my hearty thanks for his generosity. To assist identification, we shall designate the old line by yellow-inconstant-1 and MIYAZAWA's by yellow-inconstant-2. In 1930 four plants were obtained from his seeds, one green and three yellow-inconstant-2. These yellow-inconstant-2 plants bore yellow leaves with some green patches, but scarcely conspicuous enough to be set down as mosaics. On selfing they gave the progenies shown in Table II.

TABLE II.

Pedigree No.	Green	Mosaic	Yellow-inconstant-2	Total
4	88	—	—	88
1	4	13	13	30
2	14	21	26	61
3	34	86	43	163
Total	52	120	82	254
Percentage	20.5	47.2	32.3	100

The proportion of the green and mosaic plants is very high compared with that observed in my own strain. The mosaic plants showed variegation of green and yellow, frequently showing chimerical arrangement of the two parts in a sectorial or a periclinal form. In Table III are given additional data obtained from the succeeding generation.

Of seven green plants, one proved to be homozygous and the others heterozygous. In the segregating green pedigrees, the fre-

quency of the yellow-inconstant-2, including the mosaics, was very

TABLE III.

Pedigree No.	Green	Mosaic	Yellow-inconstant-2	Total
		Offspring of green plants		
1—9	55	——	——	55
1—3	14	1	0	15
1—10	38	2	2	42
2—3	16	3	0	19
2—6	96	13	7	116
3—1	14	2	3	19
3—2	32	4	6	42
Total	210	25	18	253
Percentage	82.9	10.0	7.1	100
		Offspring of mosaic plants		
2—1	39	3	2	44
2—2	33	24	13	70
Total	72	27	15	114
Percentage	63.1	23.7	13.2	100
		Offspring of yellow-inconstant-2 plants		
1—1	6	11	9	26
1—2	8	16	7	31
1—4	17	19	10	46
1—5	5	10	8	23
1—6	2	4	3	9
1—7	13	27	10	50
1—8	18	26	23	67
2—4	9	17	17	43
2—5	3	14	4	21
Total	81	144	91	316
Percentage	25.6	45.6	28.8	100

low compared with that observed in the corresponding case of the yellow-inconstant-1 (17.1 percent against 23.6 percent), the difference being mainly due to the higher mutation ratio in the former. In the yellow-inconstant-1, the mosaic plants, on account of low mutability during post-embryonic somatogenesis, may continue the

condition of the sectorial and periclinal forms rather typically throughout their growth. But since in the case of MIYAZAWA's yellow-inconstant, the vegetative mutations at times occur even in the post-embryonic somatogenesis, they naturally interfere with and complicate secondarily the original chimerical arrangements of the heterogeneous tissues, the green parts of which are due to mutations that occurred during embryonic development. Should, in addition to this, a somatic rearrangement of the tissues take place in the plant ontogeny, the mosaic nature will be more complicated. Such mosaic plants generally give a higher ratio of green variants in their progeny. Reviewing the chlorophyll variegation in the ever-sporting races, CHITTENDEN (1927) wrote: "Perhaps the most peculiar fact about these *variegata* varieties is that the green sports described all appear to be solid green. From our knowledge of other sports we should expect the periclinal condition to be the most frequent, and the solid green branches to appear only very rarely." Thorough observation however disclose some periclinal sports on other vatiegated races as well. For instance, in the variegated *Mirabilis* some sectors with yellow-over-green chimerical leaves were observed. Such periclinal chimeras are observable in all variegated tri-histogenic plants carrying mutable genes.

The offspring of the yellow-inconstant-2 recorded in 1932 contained 25.6 percent green, 45.6 percent mosaic, and 28.8 percent yellow-inconstant-2. These figures are nearly the same as those obtained in the preceding generation (20.5 percent, 47.2 percent, and 32.3 percent respectively). The average figures calculated on the basis of their total numbers (133 green, 264 mosaic, and 173 yellow-inconstant-2) is 23.3 percent green, 46.3 percent mosaic, and 30.4 percent yellow-inconstant-2, which roughly agree with MIYAZAWA's data[1] published in 1929 and 1932 (giving 11.8 percent, 58.8 percent,

1) MIYAZAWA's data were as follows:

Year	Green		Mosaic		Yellow-inconstant-2		Total
1927	67	14.0%	295	61.6%	117	24.4%	479
1929	49	10.8%	253	55.7%	152	33.5%	454
1930	4	5.0%	48	60.0%	28	35.0%	80
1931	61	4.9%	186	14.9%	1001	80.2%	1248

The 1931 data show a very high percentage of yellow-inconstant-2 and a remarkably low percentage of mosaic. The deviation seems so remarkable that we cannot ignore it and there must be some causes at work to bring it about. Excluding therefore 1931 data from the calculation, we get a total of 120 green, 596 mosaic, and 297 yellow-inconstant, which works out to 11.8 percent, 58.8 percent, and 29.4 percent respectively.

and 29.4 percent respectively). The difference in frequency of the green and mosaic variants between the two yellow-inconstant strains is evident, as stated in my former paper (IMAI 1930a). To enable more accurate comparison, new data covering the yellow-inconstant-1 are given in Table IV.

TABLE IV.

Number of pedigrees	Green	Mosaic	Yellow-inconstant-1	Total
35	120 (5.2%)	212 (9.3%)	1958 (85.5%)	2290

The following is a comparison of the newly obtained percentages with those estimated for the yellow-inconstant-2:

Stock	Green	Mosaic	Yellow-inconstant
Yellow-inconstant-1	5.2%	9.3%	85.5%
Yellow-inconstant-2	23.3%	46.3%	30.4%

The large surplus of green and mosaic in the new strain induces a remarkable deficit in the yellow-inconstant. This difference is due to unlike mutability of the two stocks.

In 1933, some F_2 derived from crosses between yellow-inconstant-1, yellow-inconstant-2, and yellow were placed under observation, the data obtained being collected in Table V.

TABLE V.

Cross	Green	Mosaic	Yellow-inconstant	Yellow	Total
Yel.-inc.-1 × yellow	3 (0.8%)	16 (4.3%)	351 (94.9%)		370
Yel.-inc.-2 × yellow	4 (1.2%)	46 (14.2%)	274 (84.6%)		324
Yel.-inc.-1 × yel.-inc.-2	8 (4.5%)	106 (60.2%)	62 (35.3%)	—	176

The proportional distribution of the green, mosaic, and yellow-inconstant in these crosses is graphed in Fig. 3, in comparison with the two homozygous yellow-inconstant strains.

The crossing of yellow-inconstant-1 with yellow diminished the proportions of green and mosaic, which however may be attributed to segregation of the yellow. Theoretically, 25.0 percent of F_2 are yellow segregates, which are fully constant, and the rest homozygous

and heterozygous yellow-inconstant-1, including their mutants. The

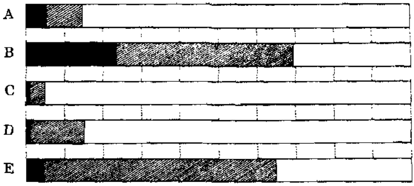


Fig. 3. Indicating the proportion of the green (black part), the mosaic (shaded part), and the yellow-inconstant (white part) in the offspring of yellow-inconstant-1 (A) and yellow-inconstant-2 (B), and in F_2 of cross yellow-inconstant-1 × yellow (C), of cross yellow-inconstant-2 × yellow (D), and of cross yellow-inconstant-1 × yellow-inconstant-2 (E).

expected percentages are therefore

Green	Mosaic	Yellow-inconstant-1	Yellow
3.9	7.0	64.1	25.0
		89.6	

The theoretical percentages show some surplus in the green and in the mosaic which, if reliable, may indicate the heterozygous effect of yellow-inconstant-1 on the rate of mutability. In the case of crossing yellow-inconstant-2 × yellow, the theoretical percentages of the respective segregates are

Green	Mosaic	Yellow-inconstant-2	Yellow
17.5	34.7	22.8	25.0
		47.8	

In the production of green and mosaic, the theoretical figures are much greater than the observed. This seems to be due to the fact that the mutability of yellow-inconstant-2 is greatly lessened in the hybrids that are heterozygous for yellow. The theoretical percentages obtained through similar treatment with data of crossing yellow-inconstant-1 × yellow-inconstant-2 is as follows:

Green	Mosaic	Yellow-inconstant
18.8	37.0	44.2

The calculation for these percentages, which was made on the assumption that yellow-inconstant-2 is dominant to yellow-inconstant-1, or that a high rate of mutability is dominant to a low, results in figures that deviate considerably from those actually observed. The percentages of the green produced is smaller, while those of the mosaic is larger compared with what were expected. It is however too early to draw any final conclusions from these data regarding the behavior of yellow-inconstant in the hybrid states.

As have been pointed out elsewhere (IMAI 1927b, 1930a; MIYAZAWA 1929, 1932), young seedlings may at times change their cotyledonous characteristics in later growth. Table VI also shows such changes in certain out-bred cultures.

TABLE VI.

Cross	Cotyledonous seedling	Full-grown plant: Green	Mosaic	Yellow-inconstant and yellow	Total
	Green	3	**1**	**0**	
Yel.-inc.-1 × yellow	Mosaic	**0**	8	**5**	370
	Yellow	**0**	**2**	351	
	Green	4	**0**	**3**	
Yel.-inc.-2 × yellow	Mosaic	**0**	8	**22**	324
	Yellow	**1**	**12**	274	
	Green	8	**0**	**0**	
Yel.-inc.-1 × yel.-inc.-2	Mosaic	**6**	52	**40**	176
	Yellow	**0**	**8**	62*	
	Green	15	**1**	**3**	
Total	Mosaic	**6**	68	**67**	870
	Yellow	**1**	**22**	687	

* All yellow-incostant.

The proportion of individuals that change their forms (in heavy type) is 2.2 percent in the cross of yellow-inconstant-1 × yellow, 11.7 percent in cross yellow-inconstant-2 × yellow, and 30.7 percent in cross yellow-inconstant-1 × yellow-inconstant-2; the proportions being greater in cases of higher mutability. The mosaic cotyledons quite frequently produce yellow-inconstant leaves, while cases in which

this is reversed alco occur at times. The other alternations, including some extreme cases in which yellow cotyledons produce purely green leaves or *vice versa*, are rather rare. In these alternation cases, the genetic types of growing points that are situated between two cotyledons differ from those of the cotyledons. The chances for differentiation are heightened in cases of higher mutability.

The frequency of the seminal mutants (majority of the green) in the two yellow-inconstant stocks differs considerably. The vegetative mutations also show conspicuous differences in their frequencies, while the times at which mutations occur also differ somewhat. In the yellow-inconstant-1, as was pointed out elsewhere (IMAI 1930a), vegetative mutations frequently take place during embryonic development, rarely during post-embryonic somatogenesis, and frequently again at a late stage of cell-generation of the leaves. Mutations occurring during embryonic development should generally give rise to mosaic cotyledons; and although the majority of them do bear mosaic or yellow-inconstant leaves, sometimes they produce green or yellow cotyledons owing to excessive growth of the mutated or prototypic areas. Mutations occurring in a late stage of cell-generation produce fine green spots in the leaves. Although the yellow-inconstant-1 plants sometimes bear leaves without such fine green spots, these spots may be found in other leaves (IMAI 1930a). No luxuriant plants that did not have spots throughout the plant growth have so far been found. This characteristic distinguishes them from the ordinary yellow. In MIYAZAWA's yellow-inconstant strains, mutations occur more frequently during embryonic development than during a late stage of cell-generation. The mutability however is somewhat high during post-embryonic somatogenesis. On account of the low rate of mutability in the late stages of cell-division in the leaves, plants with no spotted leaves may occur in the yellow-inconstant-2, remaining throughout the plant ontogeny as false yellow, that is, crypto-yellow-inconstant-2. In the manifestation of characters, the green-variegated *chlorina* leaves of *Mirabilis* (CORRENS 1910) are quite analogous to the yellow-inconstant forms of *Pharbitis*. The mutable *chlorina* stock gives green patches and branches due to somatic mutations as well as seminal mutations in the progeny. As will be referred to later, green mutated tissues also occur in the leaves of the yellowy stock of *Pharbitis*. The xanthic seedlings of this plant have vivid yellow cotyledons, on

which green patches frequently appear through somatic mutations. An analogous case, probably, was recently reported by KONDÔ and KASAHARA (1933) in breeding experiments with *xantha* seedlings from heterozygous normal rice. The total observed (sum of all the available data) was 5301 green, 1433 *xantha*, and 170 variegated, or 76.7 percent, 20.8 percent, and 2.5 percent respectively. Gene *xantha* is mutable in this case, reverting to normal. The green stripes on the *xantha* seedlings (or variegated) are due to somatic mutations, only 10.61 precent of *xantha* being variegated. In *Antirrhinum* (BAUR 1924; KUCKUCK and SCHICK 1930), some mutable chlorophyll characters have been reported, for example, *albostriata*, *flavostriata*, and *bicolor*. On the leaves of these mutants, green patches and sectors due to recurring mutations occur on the white, yellow, or yellowish white background. I have obtained *xantha*-leaved seedlings in my culture of *Hordeum* through sporadic mutation. This form very frequently exhibits somatic mutations, giving green stripes and shoots. On selfing the stock, three forms, green, variegated, and xanthic seedlings appeared in various proportions. The occurrence of the green and xanthic is due to recurring mutations from xanthic-inconstant to its dominant normal and to its recessive, the constant xanthic, which is incapable of growing beyond the seedling stage. The *albovariabilis* form of *Capsella Bursa pastoris*, reported by CORRENS (1919), may be cited in connection with these instances. In his case, a series of graded genes with different modes of mutability seems to occur in giving that complex *albovariabilis* character (IMAI, in press c). Here mutations frequently take place reversibly between unstable white and unstable green. In a variegated strain of *Commelina* now under our observation, the case seems to be analogous to CORRENS'. ANDERSSON (1930) showed that in *Polystichum* mutations in certain ontogenical stages of gametophytes regularly arise from green to white and later from white to green. All these ever-sporting cases cited above seem to be due to the mutable genes that are responsible for the chlorophyll characters.

Gene Yellowy.

The yellowy leaves, which are yellowish green at the young stage and have fine green mottling, later turn almost green. The

yellowy character made its appearance by mutation under my observation in 1928 (IMAI 1930b). The locus of the gene however has not yet been determined. In addition to the green mottled pattern, the leaves sometimes have pure green patches. On selfing, the yellowy gives rise to a mixed population in the subsequent generation. A summary of these observations is given in Table VII.

TABLE VII.

Number of *pedigrees*	Green	Yellowy (*not-green*)	Total
5	20	115	135
Percentage	14.8	85.2	100

The yellowy stock threw out 14.8 percent of green mutants. The yellowy seedlings, including mosaic, grew up as follows:

TABLE VIII.

Y	Mosaic							Total
	P	Y+G	Y+P	Y+R	G+P	Y+G+P	Y+G+R	
79	1	22	4	2	1	4	2	115

Y = yellowy, G = green, P = periclinal, R = reversal.

The full-grown plants contained 68.7 percent of plain yellowy, the remaining 31.3 percent being mosaics. Of these mosaics, one showed periclinal arrangement of tissues, that is yellowy-over-green. Other mosaics showed sectorial chimeras (yellowy and green) or compound chimeras with sectorial and periclinal situations (yellowy and periclinal; yellowy and reversal; green and periclinal; yellowy, green, and periclinal; yellowy, green, and reversal). The reversal branches are green-over-yellowy, while the green ones bear leaves entirely of green mesophyll. The green and reversal bud-variations gave rise mostly to green seedlings, segregating the yellowy ones as recessives; the periclinal branches produced mostly yellowy seedlings, as expected. These results indicate the mutable nature of gene yellowy. Genetically, gene yellowy has generally the same appearance as yellow-inconstant.

In crossing yellowy with normal, the F_1 plants obtained bore

green leaves, while in F_2, monogenic segregation occurred as shown in Table IX.

TABLE IX.

Character of F_2	Pedigree number	Green	Yellowy	Total	Percent of yellowy
	9 pedigrees	527	——	527	0.0
Green	1	72	20	92	21.7
	4	73	24	97	24.7
	5	12	2	14	14.3
	6	35	11	46	23.9
	8	52	16	68	23.5
	11	31	9	40	22.5
	12	45	15	60	25.0
	13	80	23	103	22.3
	15	60	12	72	16.7
	16	70	13	83	15.7
	17	111	16	127	12.6
	18	89	38	127	29.9
	19	74	11	85	12.9
	Total	804	210	1014	20.7
Yellowy	1	8	16	24	66.7
	2	2	9	11	81.8
	3	3	9	12	75.0
	4	1	3	4	75.0
	5	0	7	7	100.0
	Total	14	44	58	75.9

The heterozygous green F_2 segregated out yellowy seedlings, including mosaics, with an average of 20.7 percent. This low ratio is attributed to reversions of gene yellowy. The yellowy F_2 gave rise to 24.1 percent green mutants, besides many mosaics.

Variability of Flecked Flowers.

Gene flecked, which is located in the contracted chromosome (IMAI 1933), constitutes a set of multiple allelomorphs with normal and white-2b. White-2b results in a perfectly white flower, flecked in a white flower with fine flecks (stem green, frequently with color-

ed flecks), while normal manifests a self-colored flower in which anthocyanin pigment is distributed uniformly over the corolla. White-2b and normal are fully constant, whereas flecked is a mutable gene, giving at times self-colored mutants and mosaics of various chimerical forms. Since the variability in the flecked was described in an earlier paper (IMAI 1931), some additional facts recently observed will now be given.

The previous experiments were made with a stock presented by the late Mrs. T. SHIMIZU. Afterwards some cross-breeding experiments as well as some pedigree cultures were made with this strain. For the present, however, reference will be made only to the data collected in connection with the culture of the yellow-inconstant-2 stock received from Professor MIYAZAWA. This strain was originally used in the investigation of yellow-inconstant-2, and as the strain carries another mutable gene flecked, pedigree cultures were also observed for flecked.

The four plants raised in 1930 bore flecked flowers (Pl. XIII, fig. 1), and their offspring were cultivated the following season, the data being collected in Table X.

TABLE X.

Pedigree number	Self-colored	Flecked	Mosaic					Total
			I	F+N	F+I	F+II	F+N+III	
1	3	24	0	0	2	1	0	30
2	1	59	0	0	0	0	1	61
3	1	160	1	1	0	0	0	163
4	0	15	0	0	0	0	0	15
Total	5	258	1	1	2	1	1	269
					6			
Percentage	1.9	95.9			2.2			100

The culture contained 1.9 percent of self-colored mutants and 2.2 percent of mosaic variants, the remainder being flecked. The mosaic plants exhibited chimerical arrangements of tissues differing in phenotypes. Of six mosaic plants, one invariably bore self-colored flowers on its green stems (shown in Table X as Type I; Pl. XIII, fig. 3), one had green stems with flecked flowers and colored (colored means anthocyanin unless otherwise stated) stems with

colored flowers (Type F+N; for the stem and flower of Type N see Pl. XIII, fig. 2), two had green stems with flecked and self-colored flowers (Type F+I), another had green stems with flecked flowers and colored stems with fringed flowers (Type F+II; for the stem and flower of Type II, see Pl. XIII, fig. 4), while the last one comprised three forms, green stems with flecked flowers, colored stems with colored flowers, and green stems with flecked flowers having colored rays (Type F+N+III; for the stem and flower of Type III, see Pl. XIII, fig. 5). As will be dealt with fully later, the three simple mosaics, Types I, II, and III (the last two occurred in compound forms in this case), are periclinal chimeras. Type I is a flecked, covered with a self-colored epidermis; Type II, a flecked with a self-colored sub-epidermal tissue; and Type III, a flecked with a self-colored innermost component. Although the former two types were described in my previous paper, the last type is new. Out of six mosaic plants, one had green stems and invariably bore self-colored flowers. This plant is evidently a periclinal chimera, vegetative mutation having occurred early in its embryonic somatogenesis. By pronounced development of the mutated parts, the original flecked tissue had no chance to bloom flecked flowers. In other mosaic plants, the distribution of the original (flecked) and the mutated or periclinal parts differed widely, sometimes so much that one type existed as a small part of them, bearing one or two flowers, the predominant parts being the other type. With the exception probably of Type F+N, these forms of mosaics, while being sectorial chimeras, are at the same time periclinals. I raised succeeding generation of self-colored and flecked plants, including these six mosaics, the results being shown in Table XI.

Two self-colored plants segregated flecked as recessives and 10 flecked plants gave 4.7 percent self-colored, 6.0 percent mosaic, and 89.3 percent flecked, the respective proportions roughly agreeing with those obtained in the preceding generation. By totaling the results from the two generations, we have 23 self-colored, 29 mosaic, and 601 flecked (653 in all) from the flecked mothers, or 3.5 percent, 4.4 percent, and 92.1 percent respectively. In the flecked stock sent by Mrs. SHIMIZU, the data for three years comprised 227 self-colored, 38 mosaic, and 5737 flecked, or 3.8 percent, 0.6 percent, and 95.6 percent respectively (IMAI 1931). Although the self-colored mutants have nearly the same frequency of occurrence, a considera-

TABLE XI.

Mother plant	Pedigree number	Self-colored	Flecked	Mosaic: N	I	II	III	N+III	F+N	F+I	F+II	F+III	F+N+III	F+II+III	Total
Self-colored	1—1	21	5												26
	1—6	7	2												9
	Total	28	7												35
Flecked	1—2	3	28												31
	1—3	2	12	1											15
	1—5		22		1										23
	1—7	2	47				1								50
	1—8	1	65									1			67
	2—1	3	38					1	1	1					44
	2—2	3	61	1			2		1		2				70
	2—3	1	17		1										19
	2—4	3	32	1	1	2				2	1	1			43
	2—5		20		1										21
	Total	18	342	3	4	2	3	1	2	3	3	2			383
	Percentage	4.7	89.3						23 6.0						100
Type I	3—1 I		18						1						19
Type F+N	3—2 F	1	4								1				6
	3—2 N	20	14		1						1				36
Type F+I	1—4 F	1	39		1										41
	1—4 I		5												5
	1—10 F	4	13			1				1					19
	1—10 I		22								1				23
Type F+II	1—9 F		29		1						1		1	1	33
	1—9 II	22													22
Type F+N+III	2—6 F	5	36				1		1						43
	2—6 N	19	7												26
	2—6 III	3	43								1				47

ble difference is shown in the rate of occurrence of the mosaic variants, a much higher proportion being recorded in the new strain. This rather remarkable difference seems to me however to be due mainly to difference in the exactness with which observations were recorded, the new data being more accurate in the countings of the mosaics.

Some new combinations of mosaics appeared in this generation (see Table XI). Of the mosaic plants, Types I, II, and III exhibited almost invariably only one periclinal type each, while under Type N are collected plants with colored stems and self-colored flowers that were grown from seedlings with colored hypocotyls having some green parts. These plants are of mosaic origin, whose mutated parts had developed to a marked extent during somatogenesis. A special mosaic plant (Type N + III) was also recorded in a pedigree, No. 2—1, its mosaic origin being probably much more complicated. As the original part had no chance to bloom flecked flowers, the two mutated types developed into nearly the whole plant body. The other compound mosaics with sectorial and periclinal conditions, together with those cited above, are regarded as having developed from mosaic embryos.

Table XI contains records of the progeny of certain mosaic plants, the data being separate for each type of bud-variation. Since Types I and III gave results similar to those of flecked, they did not transmit their acquired characters to the offspring, whereas Types N and II, which resulted mostly in self-colored segregates, showed accompanying genic changes in their germ cells. In No. 1—9, the flecked flowers gave 4 mosaic and 29 flecked, while the fringed flowers bred true to 22 self-colored. In this case, double mutation, which occurred either singly or simultaneously, contributed to the origin of the fringed bud-variation.

Additional proof of the genetic constitution of the mosaics was obtained last summer when examining the progeny of certain mosaics that showed only one particular type predominantly, the data recorded being shown in Table XII.

The observation concerned the color of the hypocotyls in the seedling bed. Types N and II segregated into colored and green hypocotyls, the former of which will bear colored stems and self-colored flowers in the majority of cases, whereas most of the latter will have green stems and flecked flowers. Types I and II however

TABLE XII.

Types of mosaic	Number of plants	Colored	Green including mosaic	Total
N	2	128	34	162
I	4	12	238	250
II	2	215	60	275
III	3	9	214	223

gave mostly green hypocotyls, indicating that they had accompanied no genetic change in their germinal track.

The flecked plants at times bear flowers with broadly colored stripes, rarely the larger parts of the flowers being colored. When the flecked plants have more colored parts, resulting in at least a few colored flowers, the colored parts can almost always be traced to the base of the plant body; this is done easily and accurately when the colored flowers have also colored stems. This means that mutation occurred in the embryonic stage. As in the case of yellow-inconstant-1, mutation occurs rather frequently in the embryonic stage, rather rarely in post-embryonic somatogenesis and frequently again in the late stage of cell-generation. The fine flecks that occurred on the flecked flowers are believed to be due to mutations having taken place at a late stage of cell-generation of the corollas. The frequency curve of the vegetative mutation of gene flecked in the respective stages of plant ontogeny seems nearly to correspond to that in the yellow-inconstant-1. A significant difference however is observed in the frequency of the small spots occurring on leaves (in the yellow-inconstant) or on flowers (in the flecked), the spots in the flecked being more frequent than in the yellow-inconstant-1.

General Considerations on Mutability.

To the comments I have made elsewhere (IMAI, in press c) on the mutability of certain labile genes, I wish to add here some remarks, especially on the genetic and non-genetic factors that affect it.

MUTATION TO ALLELOMORPHS WITH DIFFERENT RATES OF MUTABILITY. In another paper (IMAI, in press c), I discussed the recurrent mutation of mutable genes to allelomorphs with different

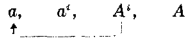
rates of mutability. As the results of such mutations, an allelomorphic group includes two or more inconstant genes, as in the cases of *Zea*, *Capsella*, *Malva*, *Polystichum*, and *Celosia*, as well as *Pharbitis*, for instance. DEMEREC (1929b) concluded that recurring mutations possibly occur in reversible ways in the unstable miniature complex, which is composed of genes miniature-alpha, miniature-beta, and miniature-gamma, all these constituting a group of multiple allelomorphs with normal. Although miniature-alpha and miniature-gamma also mutate to normal allelomorphs, which are highly constant, miniature-beta scarcely change in the same direction. In the duskish allelomorphs of *Pharbitis*, reversible changes take place between some grouping genes with different mutation frequencies.

INCONSTANT NORMALS. The stability of normal allelomorph, which is generally high, is in some cases low. In *Raphanus* (SÔ, IMAI and TERASAWA 1919) and *Chrysanthemum* (MIYAKE and IMAI, in press), recurring mutations occur from dominant red to recessive colorless. In other cases, the inconstant normals, which are mutated from recessive mutable genes, change to the original forms, the mutations recurring reversibly; namely, as exhibited in TERASAWA's *Celosia* (1922), EMERSON's *Zea* (1917), and IKENO's *Plantago* (1923). In chlorophyll variegation of CORRENS' *Capsella* (1919), inconstant normal (green) seems also to come in the same category. KONDÔ's *Oryza* (1927) and IKENO's *Erigeron* (1934) are examples of similar cases of recurring reversible mutations. IKENO, in studying inheritance in the apetalous mutant of *E. annuus*, a diploid parthenogenetic species, found a high rate of reversible mutation between *apetala* and *typica*. KONDÔ's investigation is based on his semi-sterile mutant rice, the character of which is highly labile, changing to the fertile condition. The mutated fertiles in turn frequently change to the semi-sterile state. Sometimes fertile rice gave all or almost all semi-steriles and *vice versa*. Some fertile ears of mosaic plants produced none or almost no fertiles in the progeny. These facts seem, at least in part, to be due to the periclinal nature of the ears or of the plants. In 1930, I obtained an individual showing mosaic with normal and contracted ears in a pedigree culture of a normal rice plant. Shoots of short stature bore contracted ears and had small glumes. Fertility was normal. The progeny of the contracted ears however showed only normal ears, the contracted character having disap-

peared through sexual propagation. Contracted ears are consequently regarded as periclinal, with the normal inner component covered by contracted epidermis, which results in a contracted phenotype of shoots and ears. A similar state of things is expected also in semi-sterile rice.

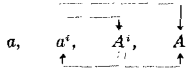
The inconstant normals of the various cases might be collected and expressed by a general formula for recurring mutations in the allelomorphic series somewhat as follows:

In *Raphanus* and *Chrysanthemum*,



In *Zea*, *Celosia*, *Plantago*, *Oryza*, and *Frigeron*,

In *Capsella*, possibly



In a hypothetical series of allelomorphs, a would represents a constant recessive, a^i an inconstant recessive, A^i an inconstant normal, and A a constant normal, the last being the prototype and the others its derivatives. Roughly speaking, the group of allelomorphs, including the two inconstant types, may theoretically be expressed by the series a—a^i—A^i—A, though frequently some of them are either absent or undetected. In some cases, the inconstant a^i consists of many grouping genes (cf. IMAI, in press c). In *Antirrhinum*, BAUR (1926b) found an inconstant line, giving a few (about 2 percent) dominant *crispa* mutants.

AUTO- AND EXO-MUTATIONS. Since the mutable genes generally transform to their allelomorphs automatically, they are called auto-mutable. The labile plastids are either auto-mutable or exo-mutable. In the white-striped *Hordeum* (SÔ 1921), variegation is indirectly due to a recessive gene carried by the stock, the gene stimulating the green plastids and altering them to white. As the mutant plastids are transmitted with their individuality to the offspring by the egg-cells, exhibiting maternal inheritance, the occurrence of white plastids is due to recurring exo-mutations of plastids,

and the gene carried by the variegated barley, although this is fully constant, acts as a stimulant in this case. In contrast to this, some variegated strains of *Oryza* exhibit auto-mutations of plastids, the inheritance being regardless of genic complex (cf. IMAI 1928). Thus recurring plastid mutations occur both automatically and transitively. Returning to the genic mutation, DEMEREC (1926, 1928a) pointed out that reddish-alpha mutates to wild-type only in the reduction divisions of heterozygous females in *Drosophila virilis*. No reversional mutations occurred in the somatic cells, in homozygous females and in males. Reddish-alpha therefore seems to be an exo-mutable gene, mutations occurring through stimulation of its allelomorphs, one of which is contained in a heterozygous condition in the females. The mutation from reddish-alpha to the wild-type occurs with equal frequency when heterozygous by yellow or by reddish-1. These allelomorphs therefore have the same potentialities for mutation. So far as I am aware, this is the only case in which recurring genic mutations do not arise automatically.

STIMULATING AND SUPPRESSING ALLELOMORPHS. The rate of mutability is either changed or unchanged according to whether the condition is homozygous or whether it is heterozygous. DEMEREC (1930, 1932b) showed statistically that the mutation rate of the rose-alpha gene of *Delphinium* is nearly the same in both cases, and that similar behavior was found in the case of the miniature-3 gamma of *Drosophila virilis*. In these cases, mutation frequency in the homozygotes was double that in the heterozygotes, in which latter the mutable genes were contained in a single dose.

The *globifera* form of *Antirrhinum* studied by BAUR (1924) frequently reverts to normal, as the result of which all the *globifera* sporophytes are more or less mosaic. As far as he has examined, the normal branches thus produced were homozygous for normal. The hybrids obtained by crossing *globifera* with normal were often homozygous. These facts seem to me to imply that the mutability of gene *globifera* is stimulated by its dominant normal allelomorph, thus bringing the heterozygous cells eventually to a homozygous condition, so that the stimulation of the normal allelomorph in the heterozygotes frequently causes them to be homozygous. In *Antirrhinum*, however, *globifera* is an auto-mutable gene and its mutability is stimulated by the presence of normal allelomorph in its heterozygous condition. A similar stimulation may possibly explain

CORRENS' *Capsella* (1919), LILIENFELD's *Malva* (1929), and KIHARA's *Celosia* (1932), in which the heterozygosity stimulates the mutability of the labile genes. Prior to these studies, EMERSON (1922) pointed out the very high rate of mutability in the heterozygous variegated ears of maize as compared with the homozygotes.

In these cases, or at least in some of them, the allelomorphs (normal or others) stimulate the mutability of the labile genes in the heterozygous state. Experimenting with *Antirrhinum*, HERTWIG (1926) made it clear that the mutation frequency in vegetatively reverting plants that were originally heterozygous for *globifera* varies according to differences in the allelomorphs of the 'Def-Serie', namely,

$$\frac{globifera}{globifera} = 100\% ; \qquad \frac{nicotianoides}{globifera} = 64\% ; \qquad \frac{chlorantha}{globifera} = 17\%$$

In the 'Def-Serie', only *globifera* is mutable, the others being constant. The percentages in the second and third formulas should be doubled because of the mutable *globifera* gene persent in a single dose in these cases. The corrected formulae are

$$\frac{globifera}{globifera} = 100\% ; \qquad \frac{nicotianoides}{globifera} = 100\% ; \qquad \frac{chlorantha}{globifera} = 34\%$$

The somatic mutability of *globifera* is therefore reduced by the suppression of allelomorph *chlorantha*, when this is contained heterozygously.

MODIFYING GENES. DEMEREC (1928b, 1929a) found in *Drosophila virilis* four genes, three dominant autosomal and one recessive, all of which modify the rate of mutation of mutable miniature. One called *M* works on miniature-alpha, and the others, *S–1*, *s–2*, and *S–3*, on miniature-gamma. Miniature-gamma, with the coexistence of either homozygous or heterozygous *S–1* or *S–3* or homozygous *s–2*, gives nearly all mosaic.

ONTOGENICAL INFLUENCES. The mutation rates of genes and plastids are greatly affected by the different stages of ontogeny. As pointed out in the preceding sections, in the yellow-inconstant-1 and the flecked of *Pharbitis*, mutation is frequently high during embryonic development, low during post-embryonic somatogenesis, and high (or very high) in the late stage of cell-generation in the formation of leaves and flowers. The yellow-inconstant-2 exhibits a very high rate of mutability during embryonic development, a little

high at the post-embryonic somatogenisis, and low in the late stage of cell-generation. In his sterile rice, TERAO (1917) found that reversion takes place at any stage of plant development, although with different frequencies for different ontogenic stages. Fertile spikelets due to reversions on their own part frequently occur, but the early somatic mutations, which include larger fertile parts, are of rare occurrence. Experimenting with mutable large-grained rice, the same author (TERAO 1922) also showed that mutation occurs at every stage of ontogeny, its frequency however being somewhat different at different stages. In his investigation of the variegated flowers of *Delphinium*, DEMEREC (1931) wrote: "Lavender-alpha gene has a high rate of mutability early and late in ontogeny, and has a low rate of mutability or is constant in the intermediate stages of ontogeny." The statistical rate of mutability however is calculated on the basis of its proportion to the observed total. ANDERSON and EYSTER (1928) attempted a survey of the variegated ears of *Zea* by classifying according to the mutation areas on the kernels of the ears. They arrived at the conclusion that the mutation in the ontogeny of the ears increases in the later cell-generations. Measuring the mutated cells of the variegated flowers of *Delphinium*, DEMEREC (1931) showed that the rose-alpha gene mutates at approximately the same rate during the last twelve cell-generations in the development of sepals. These data lead to the conclusion that the rate of recurring mutations generally differs for different stages of somatogenesis. Taking a short period of ontogeny into consideration, the mutation rate at times shows different frequencies, though frequently it may be nearly constant. The variation in the mutation rate at different stages of somatogenesis may differ widely in different species, and at times even in the same species. ANDERSSON (1930), in studying the variegated *Polystichum*, found definite stages of mutation in its gametophytic ontogeny. In *Drosophila virilis*, DEMEREC (1928a) showed that the ages of the females influence the mutability of the reddish-alpha gene. According to the investigations of ANDERSON and EYSTER (1928), in the variegated maize the position of the cell layers also affects the mutation rate. They found that mutations in the dark-crown are about 3.8 times as frequent as in the near-self mutations affecting equal areas, the mutation in the former occurring in tissues of ecto-histogenic origin and in the latter in those of endo-histogenic

origin (maize is probably a di-histogenic plant). In some variegated plants, a certain periclinal type of bud-variation is also more likely to occur than the others[1]. For instance, CORRENS' *Mirabilis*, TERASAWA's *Celosia*, and KANNA's balsam more frequently bear bud-variations with mutated ecto-histogens than with mutated meso-histogens.

SOMATIC AND GAMETIC MUTATIONS. Mosaics caused by mutable genes are evidently due to somatic mutations. As stated before, the determination of individual mutants, at least some of them, is dificult whether they are due to gametic mutation or to somatic mutation. In *Plantago* (IKENO 1923), mutation however seems to be limited to the gametogenesis. ENOMOTO (1929) found non-glutinous grains on glutinous ears of *Oryza*, but no mosaic ears. With the iodine reaction he observed a few non-glutinous pollen-grains in the glutinous anthers. In this case also mutation seems to be restricted to the gametogenesis. Some ten years ago, Mr. K. KONDÔ of the Niigata Agricultural Experiment Station, sent me microphotographs of two endosperms mosaic for glutinous and non-glutinous. These mosaic endosperms indicate that mutation rarely occurs in triploid tissues: it hardly takes place in diploid tissues. According to DEMEREC (1926, 1928a), in reddish-alpha of *Drosophila virilis*, mutation is restricted to individual mutants, no mosaics being observed. He wrote: "The mutability of reddish-α was found to be limited to a very short period of development, which has been located at the maturation divisions of heterozygous females."

The above instances are regarded as cases in which the mutation is limited or almost limited to maturation divisions, or the individual mutants are due to gametic mutations. Strictly speaking, however, even in these cases we are still not in the position to deny the occurrence of mutation at late somatogenesis or prior to gametogenesis.

Except these cases, recurring mutations generally occur in somatogenesis, probably also in gametogenesis. However, we cannot definitely say whether or not mutations generally occur in gametogenesis. The seminal or individual mutants may partly be of mosaic origin. If mutation occurs in the early embryonic stage and the

1) In two earlier papers (IMAI 1927a; IMAI and KANNA 1927) we erroneously classified the variegated forms into two or three types, unaware of the foregoing facts.

mutated tissue is followed by a prevalent growth that dominates over the original tissues, it will result in such an individual mutant. Some mutants may receive the mutant gene at the late somatic cell-generation stage, prior to gametogenesis. The seminal mutants are generally a mixture of these, probably including some gametic mutations. In the present paper, therefore, in discussing the mutable genes of *Pharbitis*, I have treated them as seminal mutants and refrained from calculating their gametic mutability.

In *Adiantum* (ANDERSSON 1923), recurring mutation occurs in nearly all stages of the plant cycle, including sporogenous stage. According to her observations, in the four (out of nine) examples in which the outcome of all 64 spores from a sporangium was recorded, odd numbers of the two, green (segregates) and pale (segregates and mutants) types were produced—a result that seems to show that mutation also occurs at the second maturation division. Should a mutation or odd mutations take place at the 6th division of sporogenous tissue, it may result in such an odd proportion. The fact that albinotic ferns appear in the green areas of the prothallia in *Adiantum* indicates the possible occurrence of gametophytic or gametic mutation at a different stage.

In the miniature-gamma of *Drosophila virilis* (DEMEREC 1928b), however, mutation occurs only in the somatic cells, producing mosaics.

DIFFERENCE IN MALES AND FEMALES. In the mutable miniature of *Drosophila virilis*, DEMEREC (1932b) found that the rate of mutation is nearly the same in both sexes, or in other words, it is twice as high in females as it is in males, then the mutation rate of the latter must be doubled in their comparison, because although the females are diploid for the X-chromosome the males are haploid.

ENVIRONMENTAL INFLUENCES. EYSTER (1926) found that different climates (chiefly temperature) affect mutability in the variegated maize. DEMEREC (1932a) however, in dealing with the mutable miniature-gamma of *Drosophila virilis*, obtained a negative result in the temperature response.

As pointed out elsewhere (IMAI 1928), since plastid mutations in both variegated barley and rice hardly occur during such times as the egg-cell stage nor during early embryonic development, we cannot generally obtain any white shoots in these cases. This limits to a certain extent the deviation in frequency of the occurrence of

albinotic seedlings. The frequency however is much influenced by differences in sowing times (IMAI, in press b), in which difference, temperature may be the major factor.

As the gene is probably a complicated molecular unit, the lability of the gene means an unstable physico-chemical condition ready to change into another stable or unstable complex molecule. For this reason the mutability of these genes may be greatly affected by certain factors. They may be affected by changes in the chemical or physico-chemical cell components, such changes being induced by cellular genetic and non-genetic factors or ontogenic and environmental influences. Since the different genes may not respond alike to the same factors, the devious ways in which the mutable genes respond to the factors that affect them are so complicated that it seems difficult to collect data under a definite scheme.

Types of Bud-Variations and their Origin.

In the yellow-inconstant-1 of *Pharbitis* are recorded two forms of periclinal chimeras, the one having a yellow 'skin' and a green 'core' and the other a green 'skin' and a yellow 'core' (IMAI 1930a), the former having the mutated endo-histogen and the latter the mutated meso-histogen, regardless of the nature of the ecto-histogen. In the present paper, I have called attention to two similar types of yellowy periclinals.

Studying the flecked *Pharbitis*, I (IMAI 1931) identified two chimerical types, one of which is flecked with a self-colored epidermis and the other flecked with a self-colored sub-epidermal tissue. U (1930) also distinguished two forms of periclinals in the pine-inconstant, while TABUCHI (unpublished data) identified the corresponding two delicate periclinals, both writers dealing with the morphological traits of this plant. In these cases, the two periclinals have different ecto- and meso-histogens, regardless of the nature of the endo-histogen. The third type of simple flecked periclinals, with mutated endo-histogen, however, is identified in the present paper. This is the first case in which the three simple periclinal bud-variations have been discriminated in a given character.

In experiments with *Celosia*, KANNA (1929), KOJIMA (1930), and

KIHARA (1932) identified two types of periclinals, the one having mutated epidermis and the other mutated sub-epidermal tissue. According to KANNA's observations on *Impatiens* (1926) and on *Mirabilis* (1933), and to DE HAAN's investigation (1931) on *Pisum*, the two types can also be discriminated by the flower color and other characters. As will be discussed later, the ontogenic origin of the plant bodies of most dicotyledonous species are tri-histogenic. If this is also the case with these plants, we should expect three types of simple periclinals as bud-variations. Recently KANNA (1934) published full accounts on the genetics of *Impatiens*, describing a subdued magenta flower with variegation that appeared as bud-sport. This may be identified as a periclinal with the mutated, self-colored endo-histogen.

EMERSON (1917) showed from his breeding experiments two periclinal types of vegetatively mutated kernels in *Zea*, the dark-crown having a mutated epidermis and the near-self a mutated sub-epidermal tissue. Maize is probably a di-histogenic plant. If so, we should then be able to obtain only these two periclinal forms from this plant.

The mutable nature of gene flecked is very useful also in investigations of bud-variation. In the flecked, the following periclinals are known:

Character	Ecto-histogen	Meso-histogen	Endo-histogen
Type I; stem green and flower self-colored (Pl. XIII, fig. 3)	Self-col.	Flecked	Flecked
Type II; stem colored and flower fringed (Pl. XIII, fig. 4)	Flecked	Self-col.	Flecked
Type III; stem green and flower flecked with colored rays (Pl. XIII, fig. 5)	Flecked	Flecked	Self-col.

In Type I, the flower color is as nearly intense as the normal self-colored mutants with colored stems. Type II blooms as a fringed flower, the corolla of which is self-colored in a dilute shade and with small colorless areas on its marginal parts, the whole surface being flecked with a normally intense color. In Type III, the characteristics are similar to the normal flecked, excepting the dilutely colored rays. Both Types I and III usually give flecked in their offspring, whereas in Type II the mutated character is inherited, the self-colored flowers predominating. Since these three forms are periclinals of heterogeneous tissues, their existence in sexual propa-

gation is only temporary. Anthocyanin color is present in the cell-sap of the tissues constituting the corolla, though the pigment is lighter in the inner tissue, whereas only the sub-epidermal cells, that is the outer tissue of cortex, are colored in the stem. Type I is flecked with self-colored ecto-histogen. It therefore bears green stems because their epidermis is always colorless. It blooms self-colored flowers because their epidermis is heavily colored, and it produces only flecked seeds. Type II is flecked with mutant meso-histogen. As anthocyanin pigment is present in the cells of the outer cortex the periclinal has colored stems. It blooms fringed flowers and gives self-colored as dominant segregates. The flowers are dilute in color, that is, the sub-epidermal tissue contains light anthocyanin pigment, the presence of which is due to the gene for self-colored, while the epidermis is colorless. The marginal white parts, or tissues, resulting in the fringing of the flower, are believed to to be formed by multiplication of the colorless ecto-histogenic cells. In maize, the dark-crown kernels have red crowns, while the near-self kernels have corresponding colorless parts, which are regarded as having an epidermal origin (EMERSON 1917). In *Celosia* (KANNA 1929, KOJIMA 1930, and KIHARA 1932), the so-called intermediate flowers, as KANNA calls them, have perianth with whitish marginal bands on both longitudinal sides. In their ontogenic origin, these marginal parts are supposed to differ from the central parts of the perianth. These examples, together with others which will be given later, may be indications that the origination of various parts of plant organs assumes at times different forms, namely, that the ecto-histogen develops into epidermis, extending certain marginal parts of the corolla in *Pharbitis*, the crown of the kernels in *Zea*, and marginal parts of the perianth in *Celosia*. In the cultivated varieties of *Rhododendron indicum*, we have a number of variegated flowers of different types. The variegated azalea frequently puts forth bud-variations of at least two types of flower coloration, the one a self-colored flower without any conspicuous 'red spot' on the upper lobes and the other a dilute flower with intense stripes and 'red spots'. In the second case, the dilute flower bas white markings on their peripheral parts (Fig. 4). I have no genetical data for these bud-variations, but it seems very probable that the first type of bud-variation has self-colored ecto-histogen and the second type self-colored meso-histogen. The substance of the white periclinal mark-

ings in the dilute flower is also considered to be derived from the ecto-histogen. The red pattern spots appear usually on flowers of self-colored varieties. The self-colored flowers that appeared as bud-sports, however, generally have no such spots because the flowers do not accompany self-colored meso-histogens by which the 'red spots' are manifested. Since the azalea is propagated vegetatively, the new bud-variation has generally one mutated histogen. The large red part with 'red spots' of Fig. 4 however appears to have two mutated histogens. The origin of the red part is believed to be either due to mutation that occurred in ecto-histogen or a somatic rearrangement of the tissues during flower development. The flecking on fringed flowers of the azalea as well as *Pharbitis*, even on the fringed white parts, is due to mutation of gene flecked to its dominant allelomorph in a late stage of epidermal cell-generation. The color of the flecks is normal in intensity, same as that of the self-colored mutants. In the ordinary flecked flower, the flecks have nearly two grades of intensity, one normal and the other dilute (strictly speaking, three grades by the addition of flecks of Type III, which are faint in color). The intense flecks are due to mutations in the ecto-histogen and the dilute to those in the meso-histogen. Since the meso-histogen carries the mutant gene self-colored, the flecks on the dilutely colored background of the fringed flower are confined to the former. In the variegated flower of other general plants, the stripes, or variegation, occur at least in the two corresponding intensities owing to the mutated cells being located differently in the flower tissues. If the heterozygotic expression is intermediate in color, the number of grades in the intensity of the stripes will be doubled. This may be the case for instance in *Mirabilis*, *Portulaca*, and *Pharbitis purpurea*.

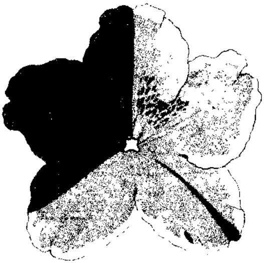


Fig. 4. Mosaic flower of the azalea. The black area represents the part in red, the dilute the pink, and the white the white or whitish.

Type III of *Pharbitis* is regarded as flecked with self-colored

endo-histogen. The stems are consequently green, the flower being flecked with faint-colored rays, while the progeny consists of flecked, including sometimes mutants. The faint-colored rays are due to the pigment in the innermost component of the corolla. Therefore the different parts of the corolla of this plant seem to be formed by multiples of different numbers of histogens, as shown in Fig. 5. If this suggestion is accepted, the larger part of the rays is only a part of what is formed in the corolla by the complete tri-histogens: such tissues may extend over the flower tubes. Being the endo-histogen self-colored, and the others colorless except the flecked parts, the rays alone should be colored in Type III. The rays are therefore faint in color, paler than the dilute color of the fringed flower, because the innermost tissue of the rays are lightest in color. The color of the rays however does not deve'op uniformly, so that the tissues that are developed from the three histogens do not seem to extend over the entire area in the innermost component of the rays.

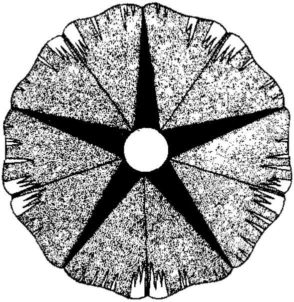


Fig. 5. The substance of the white parts are developed from ecto-histogen only, that of the dotted parts from ecto- and meso-histogens, and that of the black parts principally from a combination of the three histogens.

These three periclinals contain only a single, but different mutant histogen that produced by mono-heterogeneous bud-variation (compare Figs. 6B, 6C and 6D with Fig. 6A, pure flecked).

As stated before, bud-variations with colored stems and self-colored flowers sometimes occurred on flecked plants. This form of bud-variation should have the stem at least with self-colored meso-histogen and the flower with at least self-colored epidermis. The form therefore will have at least self-colored ecto- and meso-histogens, regardless of the nature of the endo-histogen. Whether the endo-histogen be formed from flecked tissue (Fig. 6E) or self-colored tissue (Fig. 6H), the stems at any rate should be colored and the

flowers self-colored. They probably cannot be distinguished from

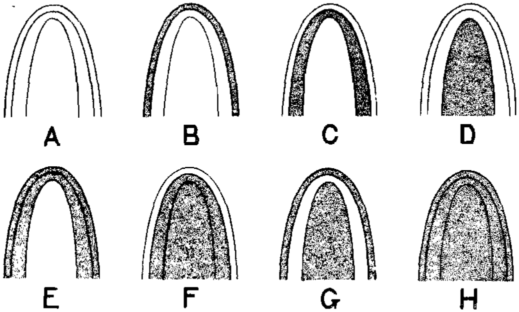


Fig. 6. A diagrammatic representation of homo- and heterogeneous growing points. The white parts are the original unchanged histogens and the dotted parts the mutated histogens.

each other by breeding tests nor from their phenotypes. Root-cutting will enable their distinction, but this method of propagation is unsatisfactory in *Pharbitis*. In the former periclinal form, the two mutated histogens are duplicated, whereas the latter form consists of homogeneous tissues or are produced as a homogeneous bud-variation. There will be another duplicated situation of the di-heterogeneous periclinal, in which both meso- and endo-histogens are of mutated tissues (Fig. 6F). This form will have colored stems and fringed flowers, probably similar to the mono-heterogeneous bud-variation with mutated meso-histogen (Fig. 6C). Lastly, we may have the third di-heterogeneous periclinal with mutated ecto- and endo-histogens, arranged alternately with the inserted original meso-histogen (Fig. 6G). The complete possible cases of bud-variations are as follows:

- Heterogeneous
  - Mono-heterogeneous
    - 1. Ecto-histogenic (Fig. 6B)
    - 2. Meso-histogenic (Fig. 6C)
    - 3. Endo-histogenic (Fig. 6D)
  - Di-heterogeneous
    - Duplicated
      - 4. Ecto-meso-histogenic (Fig. 6E)
      - 5. Mesó-endo-histogenic (Fig. 6F)
    - Alternative
      - 6. Ecto-endo-histogenic (Fig. 6G)
- Homogeneous (Fig. 6H)

Since in post-embryonic somatogenesis, including the plumules of the embryos, three histogens are differentiated, the most probable cases of bud-variations to occur during this stage is mono-heterogeneous, only one mutated histogen being involved. The production of di-heterogeneous cases, due to combination of the two mutations in the same growing point, may be of rare occurrence, while that of the homogeneous ones may be rarer still. Actually, however, the origination of bud-variations observed in the flecked and other mutable pedigrees of *Pharbitis* can generally be traced to embryonic causes. The mode of tissue development differs in the embryonic ontogeny, the three histogens being as yet undifferentiated. Therefore, at this stage mutation may result in di-heterogeneous and homogeneous growing points of stems as well as in mono-heterogeneous. Further, bud-variations may sometimes change secondarily into other types through somatic rearrangement of the tissues during plant development. In any case, alternative di-heterogeneous bud-variations may have a slight chance of being produced. Should this compound periclinal form occur in flecked stock, it may bear green stems and self-colored flowers, probably similar to the mono-heterogeneous case with self-colored ecto-histogen. This mechanism of bud-variations applies to tri-histogenic plants in general.

Since, as stated elsewhere (IMAI 1931), bud-variations newly appearing on trees and shrubs as well as on perennial herbs that have been propagated vegetatively may in most cases be due to their origination from a mutated cell during somatogenesis, they are expected in the majority of cases to be mono-heterogeneous. Such mono-heterogeneous periclinals may at times give branches that revert to the original form as the result of somatic rearrangement of tissues during plant development. Such secondary bud-variations are not rare in the periclinal morning glory. In fruit trees especially, we sometimes observe cases in which recurrent vegetative variation reverts to the original form. Some authors regard these as reversible mutation. In such cases however we cannot very well arrive at conclusions without taking into consideration the mechanism of bud-variation formulated above. The occurrence of peach-nectarine mosaic fruits was pointed out by DARWIN (1882), their behavior and structure having been studied by IKENO and NOGUCHI (1929). The mosaic in this case may however be attributed to the mutable behavior of the gene responsible for the nectarine, the

recessive gene reverting very frequently to its dominant peach the original nectarine stocks. Nectarine is therefore manifested a labile gene in certain limited cases, though it is in general to a constant recessive gene (BECKER 1923).

Di- and Tri-histogenic Plants.

The theory of chimeras, first formulated by BAUR (1909) in course of his studies in connection with the variegated *Pelargoni* solved the riddle of the so-called graft-hybrids. With the excep of such writers as NOACK (1922) and his followers this theory accepted by subsequent investigators. NOACK's own theory howe does not readily explain the mechanism of periclinal chimeras fo in various plants as well as my cases presented in the foreg pages. Some writers, such as CHITTENDEN (1927), MASSEY (19 IMAI (1930a), and others, who have fully discussed this quest are opposed to his theory. MASSEY in her anatomical studies the development of some periclinally variegated plants, gave ont nical evidence against NOACK's conception. According to her an mical observations on *Arabis albida variegata, Euonymus japo aurea,* and *E. japonica argentea,* the apex of these plants is c posed of at least three histogens. Regarding the origin of the ste she wrote "the stem apex seems to be composed of three or f distinct layers of cells surrounding an internal tissue", also t "the third layer shows undoubted division by periclinal walls some places, while in others it is imposible to tell whether the in tissue has arisen from this layer or independently." Her drawir however, seem rather to point to differentiation of the three c ponents in the stem apex as well as in the leaf apex. Long bef these studies, DOULIOT (1890) showed that the majority of dicc ledons are of tri-histogenic origin and a few others of di-histoge origin, and that the monocotyledons, with the exception of some histogenic genera, are derived from di-histogens.

On the basis of data cumulated from genetical and anatomi observations, we may draw the conclusion that the plant body the common dicotyledons arises from three histogens. For instan in the leaves the ecto-histogen develops into epidermis (frequen also into the marginal edge of the lamina), the endo-histogen i the inner mesophyll, and the meso-histogen into the remaining pa

the outer mesophyll extending to the marginal tissue on both longitudinal sides of the leaf[1]. Therefore in the white-over-green (or yellow-over-green) chimeras, the white 'skins', which are developed from the meso-histogen, extend to the chlorophyllous tissue of the bordering parts on both longitudinal sides of the leaves in its development. In these chimerical leaves, the whole (or nearly the whole) of the white parts, except the epidermis, arise from the meso-histogen. In some variegated plants the leaves show a *medio-albinata* coloration. The leaves of some variegated strains of *Aucuba, Euonymus, Elaeagnus, Hydrangea, Spiraea,* and *Pelargonium* have white (or yellow) centres with wholly white mesophyll, the marginal parts being green. Excepting the outer mesophyll of the central white tissues, the white parts of these *medio-albinata* forms correspond to the green parts of the common white-over-green chimerical leaves. As the outer central mesophyll is also white in the *medio-albinata* forms, the arrangement of green and white tissues is not periclinal. The forms give green seedlings and, from root-cuttings, put forth albinotic shoots (BATESON 1921; CHITTENDEN 1925). On account of the disorderly arrangement of the green and white tissues, the *medio-albinata* forms have been a puzzle. In my opinion (IMAI 1928) the *medio-albinata* forms are periclinal chimeras with green 'skins' and white 'cores'. The breeding results have fully borne out my views. The white plastids in these forms seem to secrete a toxic substance which, on penetrating the periclinal cell-walls of the leaves, affect the outer mesophyll and result in *medio-albinata* leaves. In *Aucuba* we have variegated stocks, the leaves of which are sometimes variegated with yellowish spots in various amounts. The yellowish spots seem to be due to yellowish plasmone, which has the same physiological activity (secreting a toxic substance), and may be produced by recurring mutation. When the yellowish spots are situated in the cells just at the growing points, bud-variations will result; namely, the *medio-albinata* and *albo-marginata* forms, and rarely also as pure yellowish branches. The first form (*medio-albinata*) is the same as that above stated, the second form (*albo-marginata*) bears periclinal leaves with yellowish 'skins'

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1) I wish to take this opportunity of correcting certain misprints in my earlier paper (IMAI 1931, p. 216, ls. 35—37). The faulty sentence is now corrected to:- "This suggests that the mesophyll of the longitudinal margins of the leaves is formed generally by the propagation of the sub-epidermal cells, and . . ."

and green 'cores'. In this case the inner green parts are apparently unaffected by the outer toxic yellowish tissues. Therefore the toxic substance scarcely diffuses into the inner tissues and into the lateral cells.

The variegated forms of *Polygonum orientale* carries a recessive gene which, stimulating the green plastids, alters them into white; or in other words, the variegation is due to the recurring exo-mutations of plastids (IMAI, in press a). The white branchlets, which sometimes appear on the variegated stocks, bear white leaves, the stipules of which however are variegated. I have never observed the so-called white-over-green or green-over-white forms, and therefore conclude that the plant body of *Polygonum* arises from two, ecto- and endo-histogens, instead of three. Judging from the variegated stipules of the white branchlets, the substance of the stipules (at least most of it) is believed to be developed from the ecto-histogen alone, which is variegated by recurring exo-mutations of plastids. The common white branchlets are therefore mono-histogenic bud-variations with the white endo-histogen, which constitutes all the mesophyll of the leaves.

According to the classic studies of DOULIOT (1890), all the tissues within the epidermis in certain dicotyledons, including *Polygonum amphibium*, are developed from a single histogen. MASSEY's drawings (1928) lead me to believe that *Veronica gentianoides variegata* is di-histogenic, the ecto-histogen constituting the epidermis and the endo-histogen all the tissues underlying the epidermis. Some years ago CORRENS (1920) used this variegated form (*V. gentianoides albocincta*) in his genetic experiments. The variegated leaves of *Veronica* have white parts on both their longitudinal margins. He crossed the variegated with the green to ascertain the genetic nature of the *albocincta* form, but obtained only green seedlings in both reciprocal matings. My opinion is that these results can be explained by the fact that since *Veronica* has a di-histogenic composition, the general tissues within the epidermis are developed from the inner component, and that the marginal parts on both longitudinal sides of the leaves are developed from the dermatogen. The ecto-histogen constitutes the epidermis and also the marginal mesophyll of the leaves, and the endo-histogen develops into the other larger parts of the mesophyll. In such an origination of tissues, the *albo-marginata* form of *Veronica* is a

periclinal chimera with white ecto-histogen and green endo-histogen. Recently, NOHARA (1933) published his work on the genetics of *Sesamum indicum*, in which he relates having observed two mosaic specimens with green and *albo-marginata* leaves. From fruits borne on variegated portions, he obtained only green seedlings. The *albo-marginata* form of *Sesamum* may consequently be analogous to that of *Veronica* in the constitution of its tissues. If so, then *Sesamum* is also a di-histogenic dicotyledon.

In both *Veronica* and *Sesamum*, the chimerical, white-over-green leaves have white margins on their longitudinal sides, whereas its converse, the green-over-white leaves of *Polygonum*, have no corresponding green margin. In some cases, therefore, in *Polygonum* at least, all the mesophyll of the leaves is developed from the tissues underlying the epidermis. In a case of this kind we have neither an *albo-marginata* nor a *medio-albinata* form.

In monocotyledons, DOULIOT pointed out that in the majority of cases the plant body arises from two histogens. From an anatomical observation of *Chlorophytum comosum variegatum*, MASSEY (1928) came to the same conclusion, regarding it as di-histogenic. According to COLLINS (1922), the *albo-marginata* and *medio-albinata* types of *Chlorophytum* gave almost one type of seedlings in the progeny obtained by self-pollinations; that is, *albo-marginata* gave green seedlings and *medio-marginata* produced albinotic seedlings. In the light of MASSEY's anatomical view, COLLINS' breeding experiments force us to the conclusion that the two variegated forms of *Chlorophytum* are evidently periclinals, *albo-marginata* being a chimera composed of white ecto-histogen and green endo-histogen, and *medio-albinata* a chimera formed by reversal arrangement of two distinct tissues. Some genetic experiments have been made with the variegated forms of *Hosta japonica* by IKENO (1917), TERASAWA (1923), and YASUI (1929). The *medio-albinata* and *albo-marginata* forms of *Hosta* are di-histogenic periclinals and they gave the same breeding results as in *Chlorophytum*.

Except in *Polygonum*, in di-histogenic plants including both dicotyledons and monocotyledons, the periclinal forms have *albo-marginata* and *medio-albinata* leaves. In di-histogenic plants, the bud-variations may have the following components:

- Heterogeneous
  1. Ecto-histogenic
  2. Endo-histogenic
- Homogeneous

All the periclinals are mono-heterogeneous, they being much simpler than those in tri-histogenic plants.

In concluding this paper I wish to express my hearty thanks to Professor K. MIYAKE for his kind encouragement during the experiments, and also to the Foundation for the Promotion of Scientific and Industrial Research of Japan for the grant from which the expenses incurred in connection with the present investigation were partly defrayed.

Summary.

1. Twenty (possibly more) mutable genes of *Pharbitis Nil*, situated in seventeen loci, are mentioned with short descriptions of their characteristics.

2. Further observations on the mutable contracted are described, with remarks on chimerical specimens.

3. Data amplifying the mutable nature of gene purple are presented.

4. All the mutable genes so far found in this plant exhibit both vegetative and seminal mutations. Recurring mutations occur from recessive to dominant; the genes come to prototypic normal, excepting in the willow, which generally mutates to maple, a recessive allelomorph to the normal.

5. Two yellow-inconstant stocks showed considerably different proportions of variants in their progeny. The yellow-inconstant-1 gave 5.2 percent green, 9.3 percent mosaic, and 85.5 percent yellow-inconstant, whereas the yellow-inconstant-2 gave 23.3 percent, 46.3 percent, and 30.4 percent respectively. These differences are due to their different mutabilities.

6. The mutation rate differs with different ontogenical stages of the two yellow-inconstant stocks; namely, in yellow-inconstant-1 the mutability is high in embryonic development, low in post-embryonic somatogenesis, and high again in the late stage of cell-generations of the leaves. In yellow-inconstant-2, however, it is very high, a little high, and low in the respective stages, varying differently in the mutation rate during the plant cycle.

7. Gene yellowy is mutable, reverting to its dominant normal.

Somatic mutations produce green, periclinal, and reversal leaves as in the yellow-inconstant. The yellowy give rise to 14.8 percent green individual mutants in the offspring, besides many mosaics.

8. The flecked pedigrees contain 3.5 percent self-colored, 4.4 percent mosaic, and 92.1 percent flecked, the former two being seminal and vegetative variants. Three periclinal forms with different arrangements of the mutated tissues were identified in connection with the bud-variations exhibited in the flecked stock. Many compound chimeras were obtained. The progeny tests of these chimerical forms throw some light on the mechanism of bud-variations.

9. Mutability and the factors affecting it have been generally considered, especially the following problems: mutation to allelomorphs with different rates of mutability, inconstant normals, auto- and exo-mutations, stimulating and suppressing allelomorphs, modifying genes, ontogenical influences, somatic and gametic mutations, difference in males and females, and environmental influences.

10. By developing and somewhat extending BAUR's theory of the chimera, the types of bud-variations have been discussed rather fully with special reference to the mechanism of the periclinals. In flecked *Pharbitis*, three mono-heterogeneous periclinals were identified.

11. The number of histogens in dicotyledonous and monocotyledonous plants is discussed in connection with variegated leaves, especially *albo-marginata* and *medio-albinata* forms.

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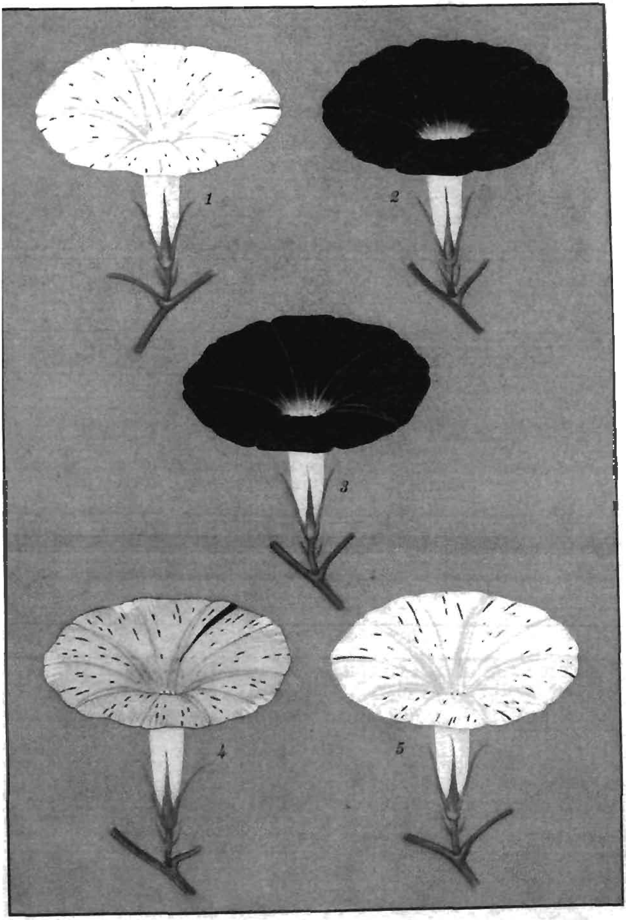
EXPLANATION OF PLATE XIII.

Fig. 1. Flecked.
Fig. 2. Self-colored.
Fig. 3. Flecked with self-colored ecto-histogen.
Fig. 4. Flecked with self-colored meso-histogen.
Fig. 5. Flecked with self-colored endo-histogen.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